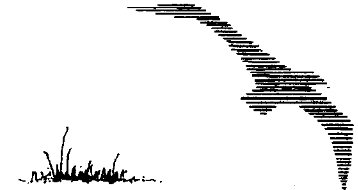
06490

HYDROLOGIC & GEOLOGIC STUDIES OF COASTAL LOUISIANA

CANALS, DREDGING AND LAND RECLAMATION IN THE LOUISIANA COASTAL ZONE



REPORT 14

COASTAL RESOURCES UNIT
CENTER FOR WETLAND RESOURCES
LOUISIANA STATE UNIVERSITY
BATON ROUGE

Center for Wetland Resources
Louisiana State University

HYDROLOGIC AND GEOLOGIC STUDIES

OF COASTAL LOUISIANA

Report No. 14

Canals, Dredging, and Land

Reclamation in the Louisiana Coastal Zone

By

Sherwood M. Gagliano

October 1973

Prepared for
Department of the Army, New Orleans District
Corps of Engineers, Contract No. DACW 29-70-C-0272

ABSTRACT

Canals, dredging, and land reclamation are examined in an attempt to determine their relationship to land loss and environmental deterioration in the deltaic coastal area of Louisiana. Map measurements within the 20,000 mile^2 coastal zone show there are approximately 189 miles^2 of man-made water bodies, more than 102 miles^2 of spoil banks, and more than 75 miles^2 of drained marsh.

Canals are related primarily to the mineral extraction industry, navigation, drainage, and lumbering. Reclamation of marshes and swamps for agricultural uses was widespread during the period from the Civil War until the 1920's, but in more recent years it has been primarily for urban development.

In addition to direct loss of habitat through dredging and spoil disposal, salt water intrusion, disruption of runoff patterns, accelerated erosion, and other secondary impacts of canals may result in severe environmental degradation. Urban encroachment into wetlands not only results in loss of valuable renewable resource areas, but flood threat and poor foundation conditions also create financial penalties for the consumer.

Modification of the deltaic coastal area has proceeded without the benefit of comprehensive regional planning. The need for effective coordinated planning between governmental agencies, as well as private development is urgent, for it is questionable that the natural systems of the area can survive another 30 years of attrition at the present rate. In the highly productive and delicately balanced coastal area, planning must follow the environmental method.

CONTENTS

FIGURES

FIGURE | Page

TABLES

INTRODUCTION

The coastal Louisiana lowlands are laced with manmade channels (Fig. 1). In the vast near-sea-level plain of the Mississippi Delta, canal dredging has proceeded hand-in-hand with utilization and development of the area. Certainly the construction of canals is justifiable for such purposes as flood control, navigation improvement, land reclamation, and mineral exploitation. However, it is widely recognized that such attempts to improve and utilize the natural environment are often detrimental. Many effects are impossible to predict and can only be evaluated historically.

Two general categories of canals can be defined. The first consists of the true canal, an artificial watercourse cut through land. The second type involves modification or canalization of an existing natural channel by straightening and/or deepening.

Canalization of natural streams invariably alters their flow regime. In upland areas canals may change runoff characteristics, usually improving drainage. In lowlands they alter both runoff and storage and may also seriously upset natural circulation patterns and water chemistry. In general, although the effects of canals on wetland environments are difficult to evaluate, it is likely that they are more pronounced than in uplands.

The first and most obvious effect is the direct conversion of land to water. Superficially this may appear to be a small factor, but it has been of major importance in south Louisiana. The marginal areas of an estuarine basin are frequently converted into potential agricultural

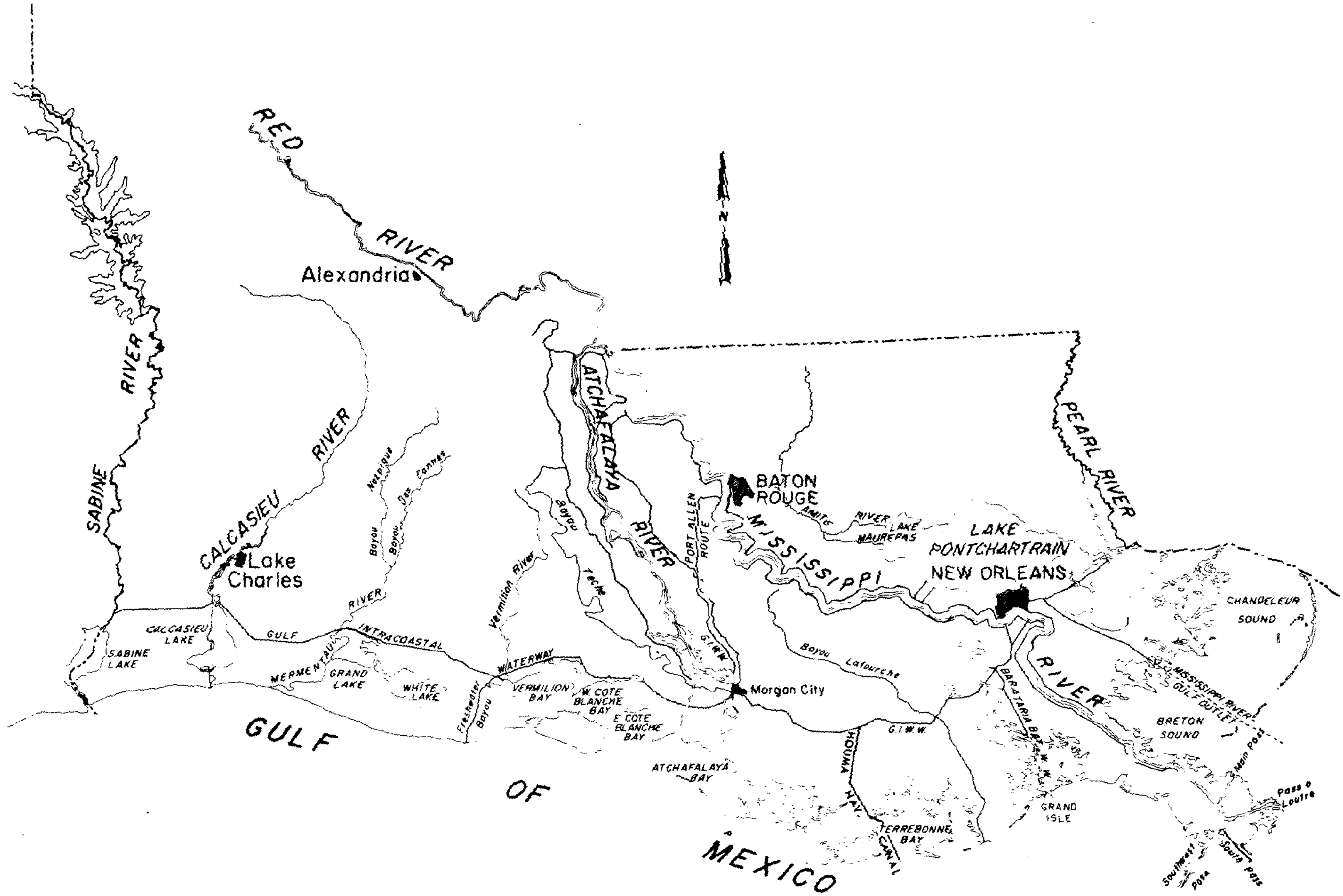


Figure 1. The Louisiana coastal area.

areas by improved drainage. The freshwater storage and "lag time" of freshwater runoff may be altered by canal construction. If canals are constructed across the "natural grain" of the stream network in an estuary, canal spoil may retard runoff.

Canals are an essential part of the process of urban and industrial encroachment into wetlands. The coastal reclamation techniques of the Dutch, involving dikes, drainage canals, and pumps, have been applied extensively in the Greater New Orleans area. Canals and associated spoil banks may also become corridors along which development is directed into estuarine areas.

In the brackish to saline zones of coastal estuaries canal construction may have catastrophic effects on the environment. Canals in an estuary system, regardless of their size, alter water circulation in some way. A straight channel with a rectangular cross section is not only more efficient for drainage but provides more rapid and direct ingress for seawater.

Consider, for example, the highly sinuous tidal stream network that develops under natural conditions in saline and brackish marsh zones. The sinuosity and branching pattern of such a system is in delicate adjustment to the runoff and tidal water exchange for that portion of the marsh which it serves. It is, in effect, the control valve or thermostat for water levels, water chemistry, and temperature, and indirectly it controls flora and fauna. When a natural tidal channel is replaced by a canal, environmental change invariably follows.

EXTENT OF CANAL NETWORK

Recent attempts to inventory and measure coastal Louisiana water bodies emphasize the extent of the canal network. Barrett (1970) measured 4,572 miles of canals in the area south of the Intracoastal Waterway (including lakes Pontchartrain and Maurepas, the total area studied comprised 11,055 square miles). In the same area there were only 7,227 miles of natural channels (bayous and passes).

Surface areas of large water bodies were measured by planimeter; canals and streams were determined by multiplying the measured length by average widths. Maps of various scales were used, ranging from 1:250,000 to 1:24,000. Dates of individual maps also varied considerably, ranging from 1948 to 1969. Although the status of mapping in coastal Louisiana has been generally very good, in some instances the most recent maps were 21 years old. A summary of the Barrett data most pertinent to this discussion is presented in Table 1.

Another study which produced an equally valuable set of measurements was done by Chabreck (1971). Chabreck's measurements were a byproduct of a helicopter survey of marsh vegetation and soils. Sampling was done at 0.25-mile intervals along north-south traverse lines spaced at 7.5 minutes of longitude along the coast. The total study included 12,224 miles^2, and determinations of surface features were made at 7,127 points. From this sampling, surface areas of various water body classes were calculated.

In 1969 the author and his associates initiated still another attempt to measure certain surface characteristics of the Louisiana coastal zone. A major goal was to determine if there had been a net

Table 1

Surface Areas of Canals as Determined by Three Surface Type

Studies in the Louisiana Coastal Zone

Source	Methodology	Total Study Area Mi^2	Total Water Area Mi^2	Canal Area Mi^2
Barrett (1970)	Map measurements various dates & scales	11,055	5,280	66.00
Chabreck (1971)	7,127 pts. sampled by Helicopter survey	12,224	6,476	90.00
Gagliano, et al (1970)	point count samples of 2 series of maps, 80,560 pts. per series	20,480	6,608	189.13

gain or net loss of land in the Mississippi deltaic area in modern times. U.S. Geological Survey maps at scales of 1:24,000 and 1:62,500 were used. A grid sampling of maps made at various dates was used to determine land and water areas at several mapping intervals. These, in turn, were used to establish rates of change of land/water ratio. Some 80,580 sample points were evaluated in a study of the 20,480 miles^2 area. The study determined that land is being lost in the Louisiana coastal zone at a rate of 16.5 miles^2/year.

Among other categories of interest included in all three studies was a measure of the total surface areas of canals (Table 1).

These land loss and canal surface area figures have generated considerable comment, and a small controversy has now developed regarding the relative validity of each of the three sets of measurements. Considering the differences in measurement technique, it would be surprising to find perfect agreement, but we should expect a reasonable degree of compatibility. Probably the greatest reason for apparent measurement discrepancies is the fact that the total study area of each survey was different. The surface area of canals is both a function of canal density and total study area. Figure 2 illustrates relationships between surface area of canals and total area of study. A line of best fit through the data points suggests that results of the three studies are not incompatible.

In the simplest terms, the Gagliano et al. study (1970) involved an area of coastal Louisiana with rectangular boundaries containing approximately 20,400 square miles. Regular segments of this area had been mapped during two time intervals. Thus, map representation of

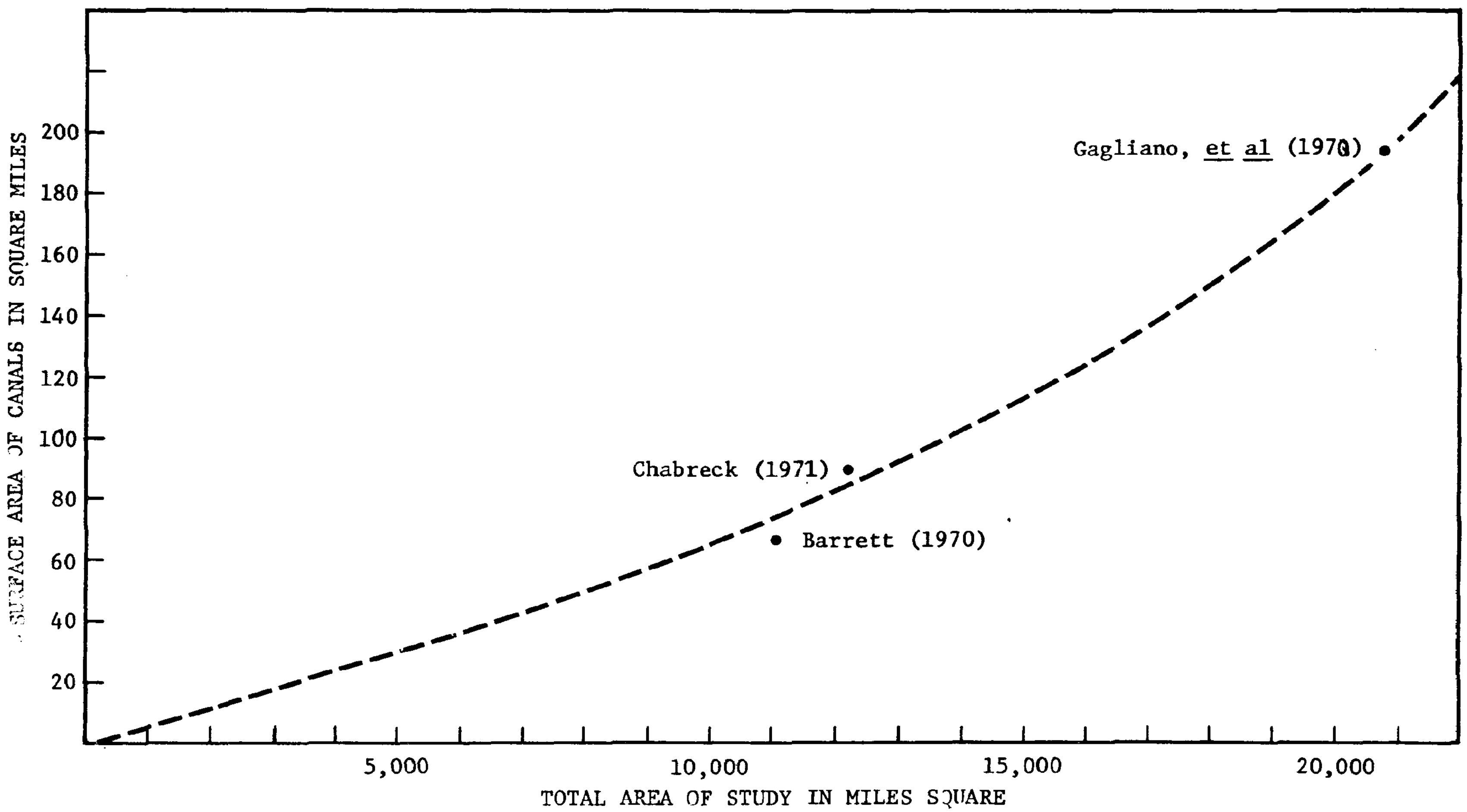


Figure 2. Area of canals as a function of the size of the area studied.

each of 316 map segments was available at two different dates. A grid sampling plan was devised to inventory types of surface configuration recorded on the maps for each time interval. Differences between total values for each category represented the amount of change. Data were expressed in terms of area of each surface type, and, using the elapsed time between the average date of each map series, rates of change were calculated. A summary of pertinent data is presented in Table 2. Because the average date of the most recent map series is 1959, it was useful to extrapolate the data, using rates of change to 1970. Figure 3 illustrates rates of change for totals of major categories. Since the boundaries of the study area remained constant through time, changes in area of water surface become a measure of land loss. As shown in Figure 3, the rate of land loss increase directly attributed to man's activities is greater than the rate of increase due to "natural causes." Further, this manmade land loss has become significant only since about 1930. The area of manmade water bodies has increased at an alarming rate during the period from which measurements are available. Although not measurable at this time, it should be recognized that the increase in area of manmade water bodies has had a secondary effect of increasing the rate of loss attributed to "natural causes." Changes in freshwater runoff characteristics, salt water intrusion, and increase in volume of the tidal prism are all factors related to canal dredging and ponding.

Table 2

Surface Area of Natural and Manmade Water Bodies, 1931-1942, 1948-1967, and 1970

Date or Interval	Total Water Area Mi^2	Natural Water Bodies Mi^2	Manmade Water Bodies Mi^2	Canals Mi^2	Ponds Mi^2
1948-1967 maps	6608.17	6381.12	227.05	189.13	37.93
1931-1942 maps	6231.82	6175.25	56.57	40.28	16.29
	376.35	205.87	170.48	148.85	21.64
1970 (projected)	6797.98	6505.31	292.67	245.87	46.80

Elapsed period between the average date of the two series of maps from which the measurements were taken equals 22.8 years. Using the figures above and this elapsed time the following rates can be calculated:

Total rate of land loss	16.51 mi^2/year
"Natural" land loss	9.03 mi^2/year
Manmade land loss	7.48 mi^2/year
Land loss attributed to canals	6.53 mi^2/year
Land loss attributed to ponds	.95 mi^2/year

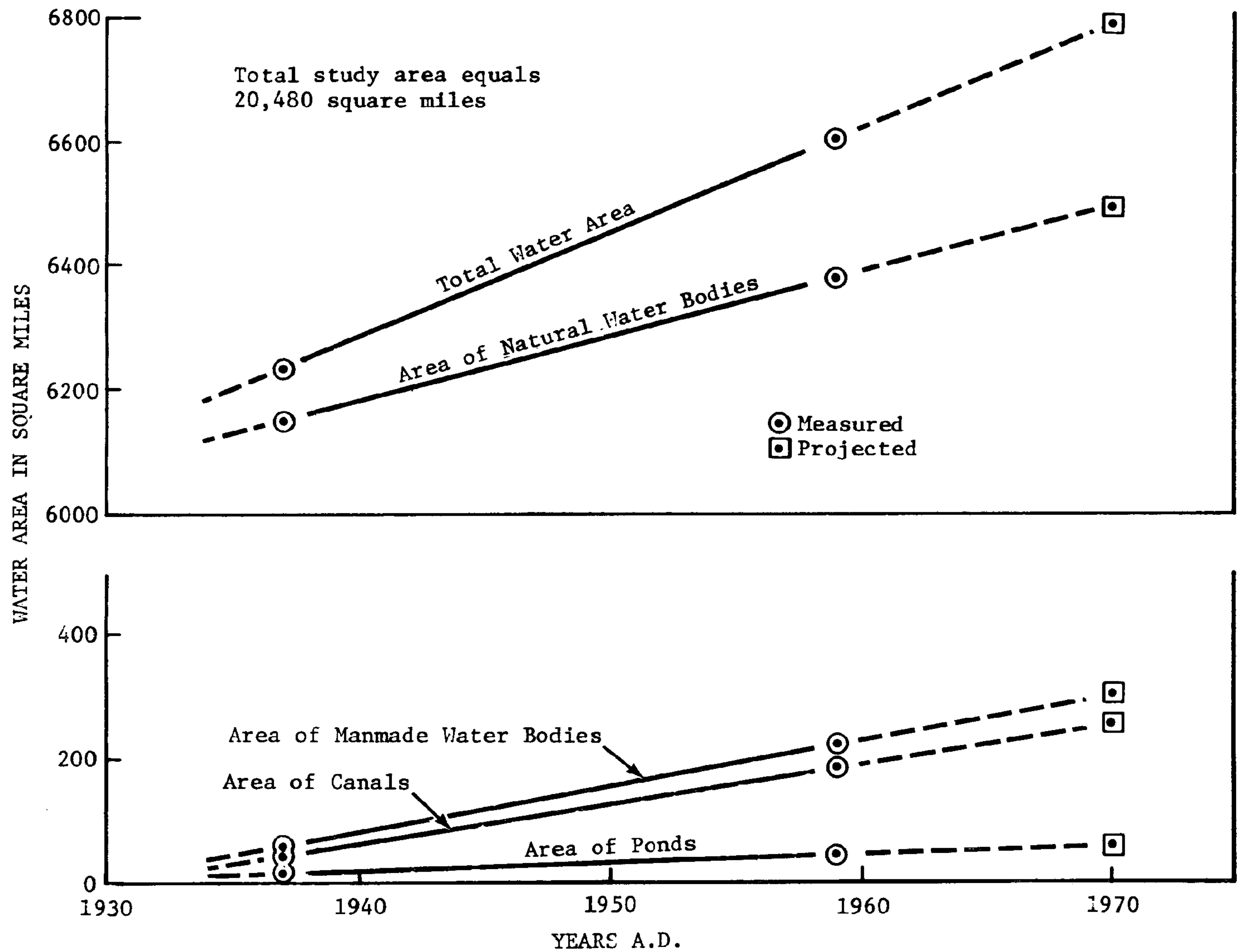


Figure 3. Changes in area of water surface as a measure of land loss in the Louisiana coastal zone.

DRAINAGE AND LAND RECLAMATION

Agricultural Projects

Soon after their arrival in the early 18th century, French colonists initiated land reclamation programs in Louisiana. Early settlements followed narrow, winding natural levee ridges that flanked the master channel of the Mississippi River and several of its major distributaries. Because of frequent flooding in these areas, the settlers were challenged from the very first to institute flood control and drainage measures, which were in effect a form of land reclamation. Early efforts were carried out by individual landowners and were restricted to the natural levee ridges. According to Okey (1918), backswamp or floodbasin reclamation was delayed by three important factors:

1. The entire area was subject to overflow from the Mississippi River
2. Abundance of cheap and well-drained agricultural land in this and other parts of the country made reclaimed marsh and swamp land unattractive
3. There were no State laws providing for drainage districts.

During the period from the Civil War to 1900 many tideland developments were attempted, but proximity to the coast made them susceptible to storm-generated tidal surges, and most failed. The wave of reclamation that came after 1900 centered farther inland on marshes not quite so vulnerable to Gulf winds and storm tides, but many of these also failed.

Between 1915 and 1920 drainage projects, still mainly agricultural, reached a peak in Louisiana. After this period there were few attempts at land reclamation until the 1960's, when a number of new urban and industrial developments were started. Many of the reclaimed areas in operation today (Fig. 4) are carryovers from the 1915-1920 period and have operated as agricultural holdings only through heavy subsidy (Harrison, 1948).

Inadequate drainage district laws were largely responsible for project failures. In 1906 the State Legislature provided that the Board of State Engineers should make a survey of proposed developments to determine the feasibility of reclamation. Reclamation interests (sales agents for marshland companies and jobbers of reclamation bonds) overstated the role that the Board of State Engineers was to play in making marsh reclamations sound investments (Harrison and Kollmorgen, 1947). In many instances the State engineers approved plans without visiting the projects, and in no sense did they exert any judgment as to the desirability or feasibility. Many of the drainage systems installed between 1905 and 1920 were engineered without regard to or understanding of the requirements of the physical setting. Social and political considerations frequently determined the locations of the drains, levees, and dams (Harrison, 1947).

Owing to understaffing of the Board of Engineers, consultants were sometimes appointed to make inspections; generally, however, once the project had left the department with a seal of approval, it was not monitored (Harrison and Kollmorgen, 1947).

Okey (1918) reviewed the status of wetland reclamation and included a map of coastal Louisiana projects in his 1918 publication. A brief status report of the better known projects was given by Harrison in a

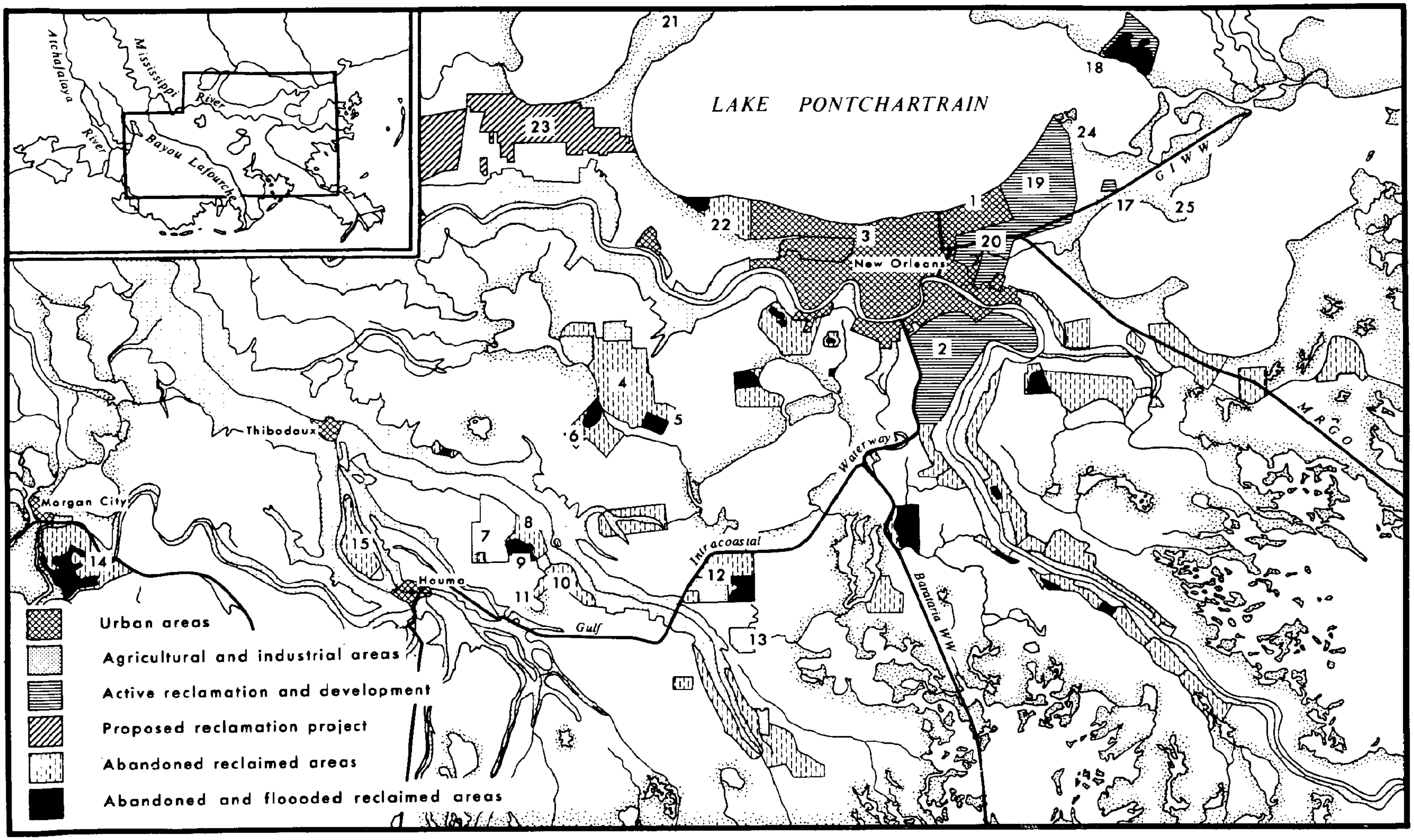


Figure 4. Land reclamation projects in southeastern Louisiana.

monumental work on land development in the alluvial valley of the lower Mississippi published in 1961. Project locations are shown in Figure 4, and Harrison's report is quoted as follows:

> (1)* New Orleans Lake Shore Land Company [1908]; 7,000 acres. Failed as agricultural undertaking; subsequently much land bought by speculators interested in holding it for industrial or residential sites.
>
> (2) Plaquemines-Jefferson Drainage District; 37,500 acres. Less than 8,000 acres farmed at present, much idle and waste land. Pumping facilities inadequate.
>
> (3) Jefferson Drainage District No. 4 and related subdistricts [1915]. Largely industrial and residential.
>
> (4) St. Charles Municipal Drainage District No. 1, also known as Sunset Drainage District; about 10,000 acres. (Several projects started in this area in early 1900's; only one remains.) Flood overflowed district in 1912. Drainage local and inadequate. Only 25 to 30 percent of land in agriculture, used mainly for pasture and forage crops. Land now owned by corporation and oil deposits being developed. Once settled by Corn Belt farmers; all of them now displaced. (See Allemands Quadrangle, U.S. Geological Survey.)
>
> (5) St. Charles Drainage District No. 1 [1910]; 2,800 acres. Drowned fields now used by duck hunting club.
>
> (6) Lafourche Drainage District No. 6 [1910]; 1,800 acres. Drowned fields now used by duck hunting club. (See Allemands Quadrangle, U.S. Geological Survey.)
>
> (7) Lafourche Drainage District No. 12; 8,265 acres, composed of subdistricts listed below. Part of project is above local water level and has loamy soil favorable for corn. Lower areas never suitable for small farmers. Corn Belt farmers failed. No intensive use of land developed and corn remains principal crop, although some grass seeds have been produced. (See Houma Quadrangle, U.S. Geological Survey.)
>
> (8) Subdistricts 1, 2, 3 of Lafourche Drainage District No. 12 [1907]; 835,940 and 2,250 acres respectively. Small farms at first sold to Corn Belt farmers, who failed. Small farms in area took over but have not made success of farming. No high-value crops produced and high drainage taxes met with difficulty. Now extensive repairs and renovations

---

*Location shown in Figure 4.

necessary and no money for this work is in sight.

(9) Subdistrict 4 of Lafourche Drainage District No. 12 [1913]; 41,240 acres. Became the property of engineering company which developed Nos. 7 and 8 above. Operated as private holding along plantation lines, specializing in beef cattle. Serves as a kind of luxury farm on which expenses have been heavy, profits from agriculture rare and subsidies have been common. Oil now helps sustain operations.

(10) Smithport Plantation [1907]; 847 acres. Original drainage reservoir capacity inadequate and so was enlarged. For a time land was well drained, although tropical storms did serious damage and hindered pumping operations. Serious condition of soil acidity developed after several years of farming. Project now abandoned. (See Houma Quadrangle, U.S. Geological Survey.)

(11) Lafourche Drainage District No. 13, Subdistrict No. 1 [1914]; 2,000 acres. Development cost underestimated and project abandoned after spending funds from $60,000 bond issued. (See Houma Quadrangle, U.S. Geological Survey.)

(12) Delta Farms (4 units) [1910-1913]; acres range from 600 to 3,000 acres. Three smallest units abandoned, one of them now serving duck hunting club. Large unit of 3,000 acres survived with heavy losses and subsidies. Changed ownership several times and is now owned by corporation. Owners interested in oil prospects. Operated as stock farm; corn main cultivated crop. Levees and drains in deteriorated state. One of two major pump projects that survives.

(13) Clovelly Farms, Subdistrict No. 1 of Lafourche Drainage District No. 20 [1916]; 2,500 acres. Private reclamation developed by Northern man as demonstration project. At first operated under tenant system, which failed; now operated under central management. Problems similar to those of other projects but efforts to succeed more persistent. Newly drained land was difficult to cultivate. Bogshoes on horses and special plowing equipment were used. Seven to eight years elapsed before soil was sufficiently dry to be plowed readily and by that time soil was so acid that crop production seemed impossible. Sulphates left by sea water turned acid as they decomposed. Application of lime offered only partial relief. Twelve to 16 tons of calcareous sand applied per acre and mixed with peat soil to improve its structure. Now potatoes, corn, cane, cotton and several vegetable crops are grown. Pasture and livestock programs are small. It is still difficult to keep the project o of the red and much investment must be charged to experimentation.

(14) Avoca Drainage District [1912]; 13,200 acres. Project seriously damaged by flood of 1927. Over one-half million dollars spent on project. Fields are now flooded and serve duck hunting club.

(15) Upper Terrebonne Drainage District [1912]; 4,240 acres. Storms and seepage proved major problems as did disagreements between settlers and land development company. Project abandoned.

(16) Various other projects [1912]. All abandoned.

The history of Lafourche Drainage District No. 6 (also known as the Des Allemands Drainage District) illustrates some problems common to nearly all of these early reclamation schemes. This site is located on the western side of Bayou Des Allemands in Lafourche Parish (Fig. 4). A sketch map showing the original arrangement of the levees and ditches is shown in Figure 5. The following description is taken from Okey's 1918 report:

> This tract had been drained in the latter part of 1911. It lies on the western side of Bayou Des Allemands and south of the Southern Pacific Railroad. A portion of the town of Des Allemands is located in the northeast corner of the district. The land is from 1 to 2 feet above the ordinary stage of water in the bayou and a large percentage is made up of firm silt ridges with a very thin layer of muck on the surface. Old muck-filled bayous, having widths of from 100 to 200 feet, occur at intervals. The muck in these is from 4 to 8 feet in depth. However, the land mostly is quite firm, the proportion of soft ground being about 10 per cent. The average depth of muck was from 8 to 18 inches. Except for a few scattered trees on the ridges, the land originally was covered with the usual heavy growth of natural prairie grass.
>
> On one side the embankment of the Southern Pacific Railroad serves as a levee and on the side bordering the bayou an almost continuous ridge of silt, averaging about 2 feet above ordinary water level, makes an excellent foundation for the levee. This levee was built in two layers by a floating dredge with material taken out of the bed of the bayou. The height is about 5 feet, the top width from 6 to 12 feet and the side slopes 1 1/2 to 1. After the first layer of material was placed in the levee a muck ditch about 3 feet deep was dug along the inside toe of the slope and when the second layer of material was placed

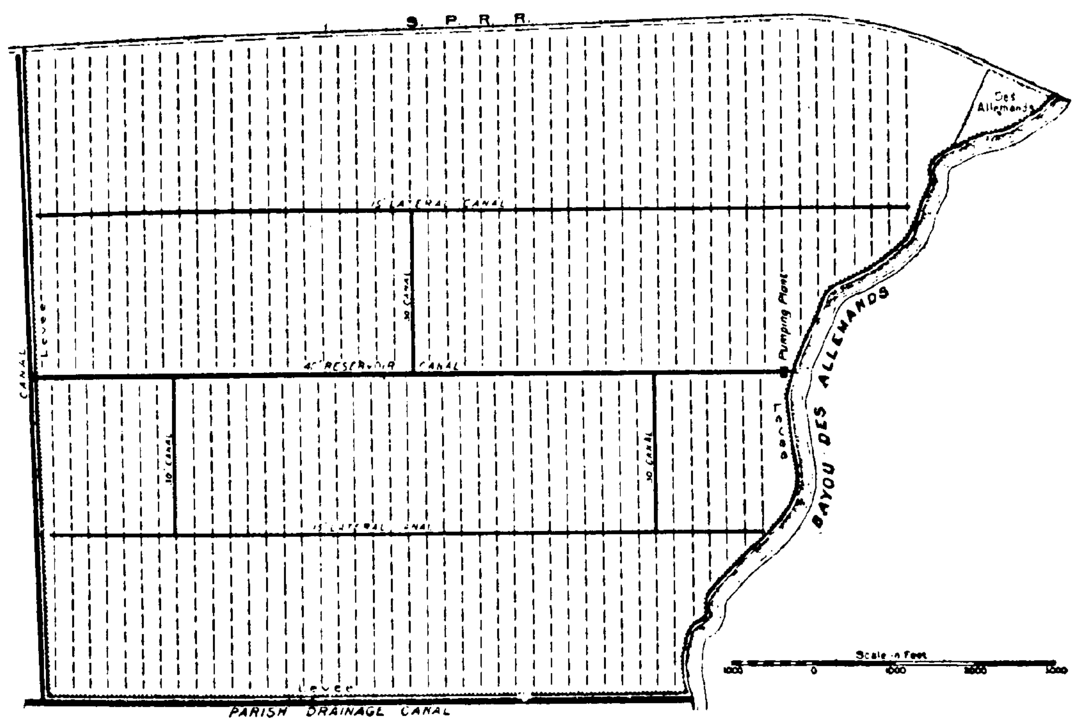


Figure 5. Arrangement of levees and ditches in the Des Allemands Drainage district. (After Okey, 1918)

this ditch was filled with pure silt taken from the bottom of the bayou. This made the levee free from seepage through the base. On the other two sides the levee was located through softer land. Some years before the building of the present levee a canal had been cut along these two sides of the district. The spoil bank of this canal formed the base of the levee, although it was necessary to cut a muck ditch along the inside slope to cut off possible seepage. This portion of the levee was built up in two layers to a height of 4 feet, with a top width of from 4 to 6 feet and side slopes about 2 1/2 to 1. The berm varies from 5 to 10 feet. Except where some old muck-filled bayous were crossed, the levee is up to the above grade. Many layers of material have been placed in these soft spots. The only method that seemed to be effective in raising the levee was to bring material in wheelbarrows from the solid banks of the bayou. After each layer was placed there was some subsidence, but gradually the top of the levee was raised. After the solid material placed in the levee reaches the solid bottom of the old bayou the levee should be free from further subsiding except from the decay of the vegetable material in the soil, which will cause a gradual subsiding in all levees in this section.

On a portion of the levee in the northwest corner of the district very severe seepage conditions existed in 1912. Water appeared in springs as far as 100 feet from the levee. The foundation at this point was of solid silty clay, but examination showed that the ground had been honeycombed to a depth of several feet by muskrats or alligators. A trench about 14 feet deep was dug immediately along the inside of the levee by means of an orange-peel bucket dredge which floated in the outside canal. The material excavated from the trench was then dropped back into it from a height of about 25 feet by the same dredge and the seepage was stopped entirely. No further seepage has been noticed.

RESERVOIR CANALS

As shown in figure [5], the reservoir canals were all cut in the interior of the district rather than along the levee. By extending the canals to all parts of the tract the necessity of small collecting ditches was eliminated. A small canal gives a much better outlet to the ditches than does the collecting ditch and is easier to maintain in good condition. Such canals can be of sufficient depth to have from 1 to 2 feet of water in them to discourage the growth of grass. These canals were cut with a small dipper dredge, and the material was deposited rather too close to the sides of the canal. This resulted in a certain amount of shrinkage in the size of the canals, and by February 1912 there was from 2 to 4 feet of soft mud in them. A small hydraulic dredge was tried at cleaning out this muck but was not successful owing to faults of construction in the dredge. A large orange-peel dredge was used to clear the main canal of silt in the latter part of 1913, but the lateral canals were still in poor condition. From that time until the summer of 1916 the capacity of the canals was not sufficient to bring the water to the pump rapidly enough to secure operation at full capacity, except when the stage of the water was very high. When the canal was empty at the pumping plant the water was still relatively high in the farthest corner of the district. In 1916 these canals were cleared of soft mud and enlarged somewhat by the use of a 1-yard dipper dredge mounted on an 18-foot hull and swinging a 35 foot boom. The width of the main canal now is about 42 feet and that of the small canals about 20 feet. The average depth was increased from about 5 to 9 feet. With this increased depth and width good drainage is insured for the entire district, and the pumping plant can be operated continuously until the water at the far end of the district is lowered enough to give good drainage. Prior to this clean-out work it was necessary to run the pump a few hours and then wait for the water to come in slowly to the plant.

The canals originally were smaller on this district than has become good practice, but if they had been cleared of silt early in 1913 there would have been little interference with drainage. Such clearing out of the canals should be done after they have been cut two or three years and the district drained for a year or two. The material along these canals is now quite solid, and a second clearing of the canals should be necessary for a long term of years.

DITCHES

The spacing of the ditches on this tract is 210 feet. They are of about the usual size, 3 to 4 feet deep with a 4-foot top and a 1-foot bottom width. All discharge into the smaller lateral canals. Thus any silt which is carried along in the ditches is deposited in the small canals and does not choke up the large canals. Due to the regular shape of the district and to the good layout of canals. The ditches are all of about the same length, 2,000 feet, which has proved to be satisfactory when ditches are kept in good condition. However, in the portion of the district between the railroad and the nearest lateral canal the problem of getting the water from the far end of the small ditch into the canal has been made harder because the land near the railroad is from 1 to 2 feet lower than that near the lateral canal. As a result the ditches have had to be 5 feet deep near the lateral canal in order to give a scant 2 feet of drainage near the railroad. While the surface of most all the prairie lands is nearly flat, it is best to take advantage of the natural slopes in laying out the field ditches.

Ditching operations were started in 1911 and continued through the following years as the land was desired for cultivation. All of the land between the main reservoir canal and the railroad had been drained in 1915 with ditches spaced 210 feet apart, and the land on the other side of the main canal had been partially drained with ditches spaced about 840 feet apart. As soon as this land is needed for cultivation it will be ditched completely.

PUMPING PLANT

The pumping plant is located about 300 feet back from the bayou front, on a leveed outfall canal. This location was selected that advantage might be taken of a firm ridge of silt as a foundation for the machinery....There are two duplicate units, each consisting of a 24-inch cast-iron, double-suction, horizontal, centrifugal pump, directly connected by means of a flexible coupling to a 12 by 12 inch vertical, slide-valve steam engine. The suction and discharge pipes are tapered their entire length so that the area of the end of the intake is four and one-half times and the area of the discharge pipe three times that of the discharge opening on the pump. This enlargement of the pipes probably reduces the friction and velocity head losses to less than 0.5 foot, while if they were not enlarged the losses would amount to nearly 4 feet. These pumps operate efficiently, as everything within reason has been done to cut out unnecessary losses. Steam is furnished by two Scotch marine boilers, burning fuel oil. This type of plant is reliable and easily operated, but uses considerable more fuel oil than does the best type of steam engine or an internal-combustion engine. Both units have been run for periods of four or five days without stopping.

The pumping plant was designed to take care of 1/2 to 1 inch of runoff in a 24-hour period. However, since rainfall in excess of 4 to 5 inches in 24 hours is not uncommon in this area, the pumps were completely inadequate. Once the project was drained to the point where cultivation was possible, it was found that the high organic nature of the soils was suitable to a number of crops, principally sugar cane, corn, and oats. Maintenance problems plagued the project. The organic muck of the marsh is unsuitable for fill and provides very poor foundations, so that the levees sank and deteriorated rapidly. Seepage was a common problem, as was breaching by storm surge during hurricanes. Shrinkage and oxidation of the organic soils soon reduced land level to -3 to -5 feet below mean gulf level, further complicating the seepage and drainage problem. The project eventually failed and is conspicuous today on maps and aerial photographs as a series of ponds divided by traces of the former levee system (Fig. 6).

The numerous rectangular lakes that dot the marshes of coastal Louisiana are monuments to poorly conceived reclamation schemes similar to the Des Allemands project. Old agricultural areas along the south shore of Lake Pontchartrain have been revived in recent decades as areas of urban development. As mentioned previously, the few surviving reclamation projects that are still devoted to agriculture operate only through heavy subsidy.

It is of particular interest that all these early agricultural developments were land sale promotions directed almost exclusively at Corn Belt and Lake State farmers. Vigorous advertisement campaigns were launched to bring settlers into the area. Only in rare instances were local farmers considered suitable as tenants or purchasers by the promoters (Harrison, 1961). Apparently the local population showed no special interest in the intensive type of farming that was needed to support reclamation projects.

When this early era of land reclamation is viewed in historic perspective, it can only be concluded that the projects were largely

Figure 6. Aerial photographs showing land reclamation projects and associated drainage canals in the vicinity of Allemands, St. Charles Parish, Louisiana. Part of the reclamation area (A) has been abandoned and is now flooded, forming a series of rectangular ponds. Shrinkage and oxidation of organic matter in the soil reduced the original marsh surface below sea level, creating the depressions occupied by the ponds. Micro-relief associated with the natural drainage is accentuated in the reclaimed areas (B). Spoil banks along former drainage canals remain above water level after reflooding (C). Erosion along banks of Petit Lac des Allemands threatens reclamation area dikes (D). Elevations in the vicinity of canal No. 14 are -3.0 to -3.5 feet mgl.

B
A
C
D
1952

Southern
90
Canal No 14
632
Canal No 13
Canal No 12
A
C
Petit
Lac
des
Allemands
D
Canal
1969

get-rich-quick development schemes. Time has proven that the areas were unsuited for the intended use. Although the landscape has been scarred, the environment has recovered to some extent. In fact, many of the ponds marking old fields are well known today as favorite fishing and duck hunting spots. It should not be forgotten, however, that there were many victims of these development schemes: families who invested savings in land purchase and who made honest attempts to farm it.

Land Reclamation in the New Orleans Area

Urban encroachment into wetlands is one of Louisiana's most critical environmental problems. The condition is best illustrated and most severe in the vicinity of New Orleans. The city is situated on the edge of a broad deltaic plain, but it is bounded on the north by a marginal deltaic basin occupied by several large, shallow lakes. Under natural conditions the area was characterized by a series of levee ridges bordering the Mississippi River and several of its abandoned distributary channels (Fig. 7). These natural levees were built of sediment deposited by overbank flow during high river stages. Other "high ground" consisted of small relict beaches isolated by extensive areas of fresh-to-brackish-water marsh and dense cypress swamp. Small, shallow lakes and sluggish bayous were numerous. Maximum elevations on the crests of natural levee ridges rarely exceed 15 feet, and beach ridges are seldom more than a few feet above mean sea level. In most places swamp and marsh surfaces approximate mean sea level.

The original French settlement was established in 1718 on the

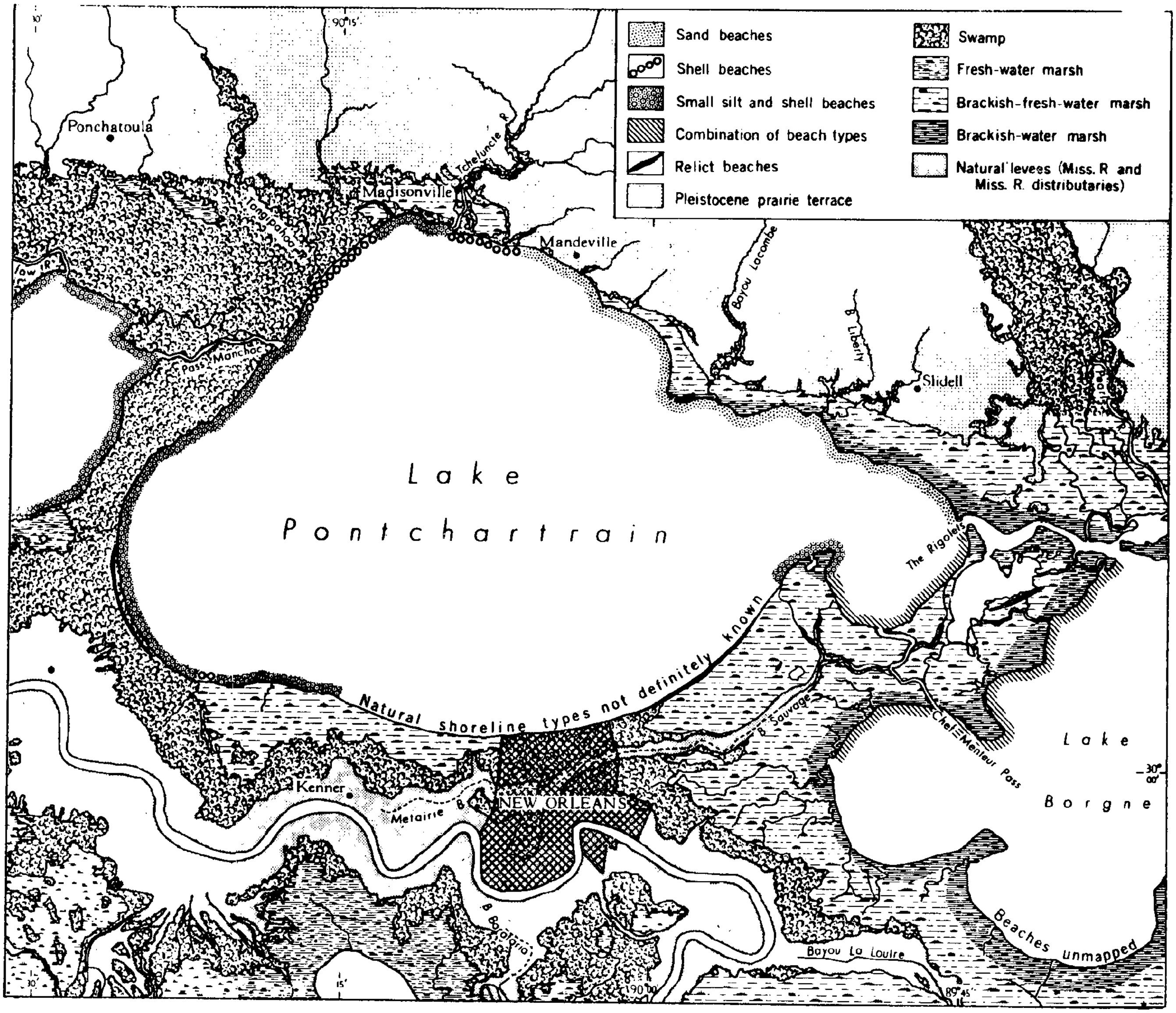


Figure 7. Geomorphic setting of the Greater New Orleans area. (After Saucier, 1963.).

broad, relatively high natural levees. Bienville chose the site because he considered it safe from tidal waves and hurricanes, which had menaced the French at both Dauphin Island, Alabama, and Biloxi, on the Gulf Coast of Mississippi. The river channel was deep enough to accommodate the largest sailing vessels, and the natural levee ridges were fertile and relatively high. It is significant that during the first few years of development drainage ditches and canals were dug and low dikes or levees were thrown up as protection from floods. Early expansion was limited largely to the natural levees bordering the Mississippi, but eventually flood basins were utilized.

By the 1880's the Crescent City was beginning to experience growth pains. In 1812 the population of the city was only 18,000, but by 1860 it had reached nearly 170,000. There were obvious reasons for its growth. By the time of the War Between the States, it was the largest trading and business center of the lower Mississippi Valley and was the most important seaport on the entire Gulf Coast. As illustrated by a Currier and Ives print depicting a panoramic view of the city as it appeared in 1885 (Fig. 8), the city had extended to the backslopes of the natural levees and had started to move into the flood basin.

This is when the trouble really started. Crests of the natural levees stand 10 to 15 feet above sea level. The Mississippi levees slope gently away from the river for approximately 1 mile, until they merge into the flood basin. Because the surface of the flood basin approximates mean sea level and tidal range in the central Gulf Coast is approximately 2 feet, under normal conditions the flood basin may

Figure 8. An artist's concept of the City of New Orleans. Published by Currier & Ives in 1885. Flood basin - natural levee boundary added.

have about a foot of standing water. However, wind-generated tides funneled into the marginal basin often cause excessive rises in water level.

Natural levee deposits, which accumulate during overbank flooding, are composed of laminated silts and clays and provide a relatively firm foundation. However, the engineering properties of flood basin deposits are not so desireable (Fig. 9). The predominant material is clay, with varying amounts of organic matter, peats, silts, and sands which accumulate in marsh, swamp, and lacustrine environments. The proportion of poorly consolidated clays and peats is very high. They are characteristically soft, and their load-bearing capacity is poor. Furthermore, when dried they shrink appreciably, with a volume reduction of as much as 50 percent or more in the peats. The clays, if dried completely, would shrink a maximum of 10 to 15 percent by volume, but may have the additional characteristic of swelling if water is added after drying. When exposed to oxidizing conditions, through such means as diking and draining, the organic fraction may be lost.

During the period between 1885 and 1940 the city expanded progressively into the marshes along the southern shore of Lake Pontchartrain (Fig. 10). Reclamation was first accomplished by constructing dikes around the marsh areas to be developed. At the same time, canals were dug and pumping stations were located within the city, with auxiliary pumps along the lakeshore and points along the canals. After initial drainage, the canals functioned as a means of removing rainwater and sewage. Subsequently, many of the canals have been converted intp concrete tunnels that accomodate sewage and/or storm runoff (the systems are separate) and underlie major avenues and boulevards throughout the city.

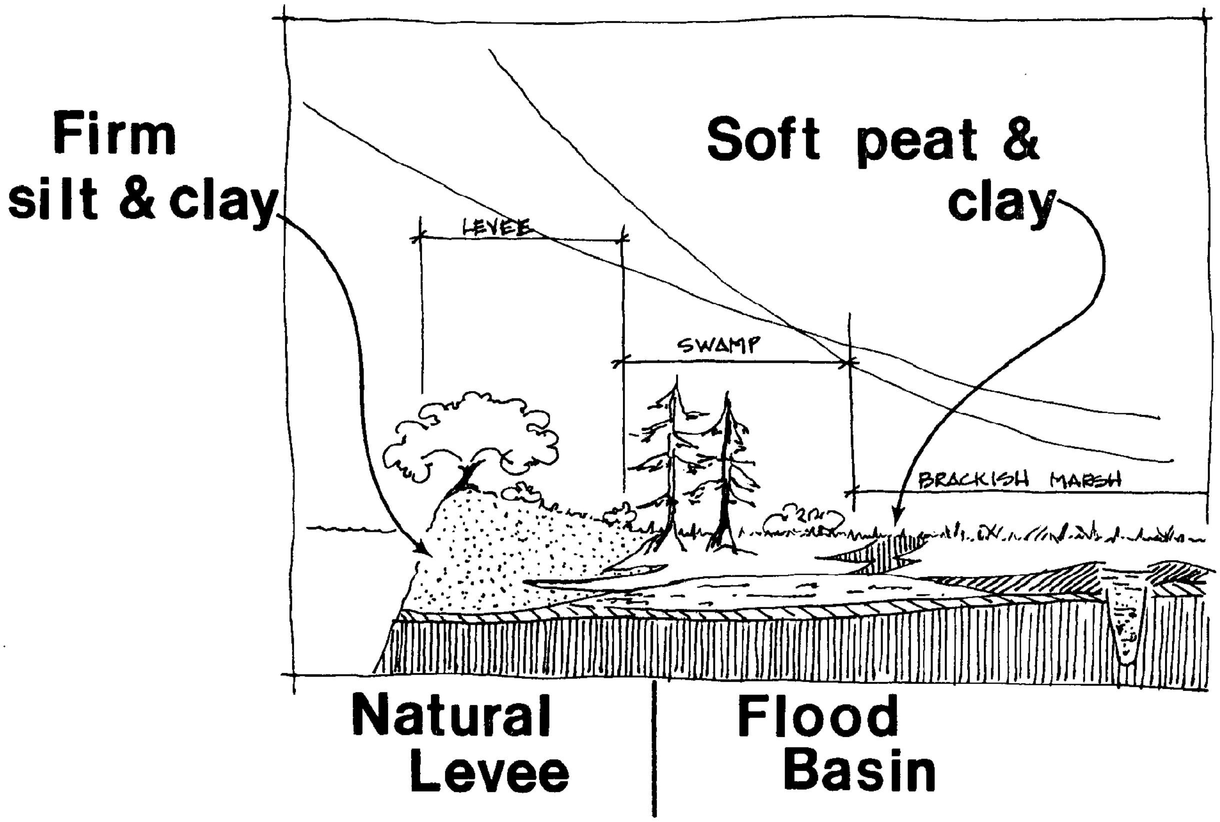


Figure 9. Idealized cross section of natural levee and flood basin environments in the New Orleans area. In general, levee ridges have relatively good drainage and foundation conditions, while flood basin areas are flood prone and have poor foundation conditions.

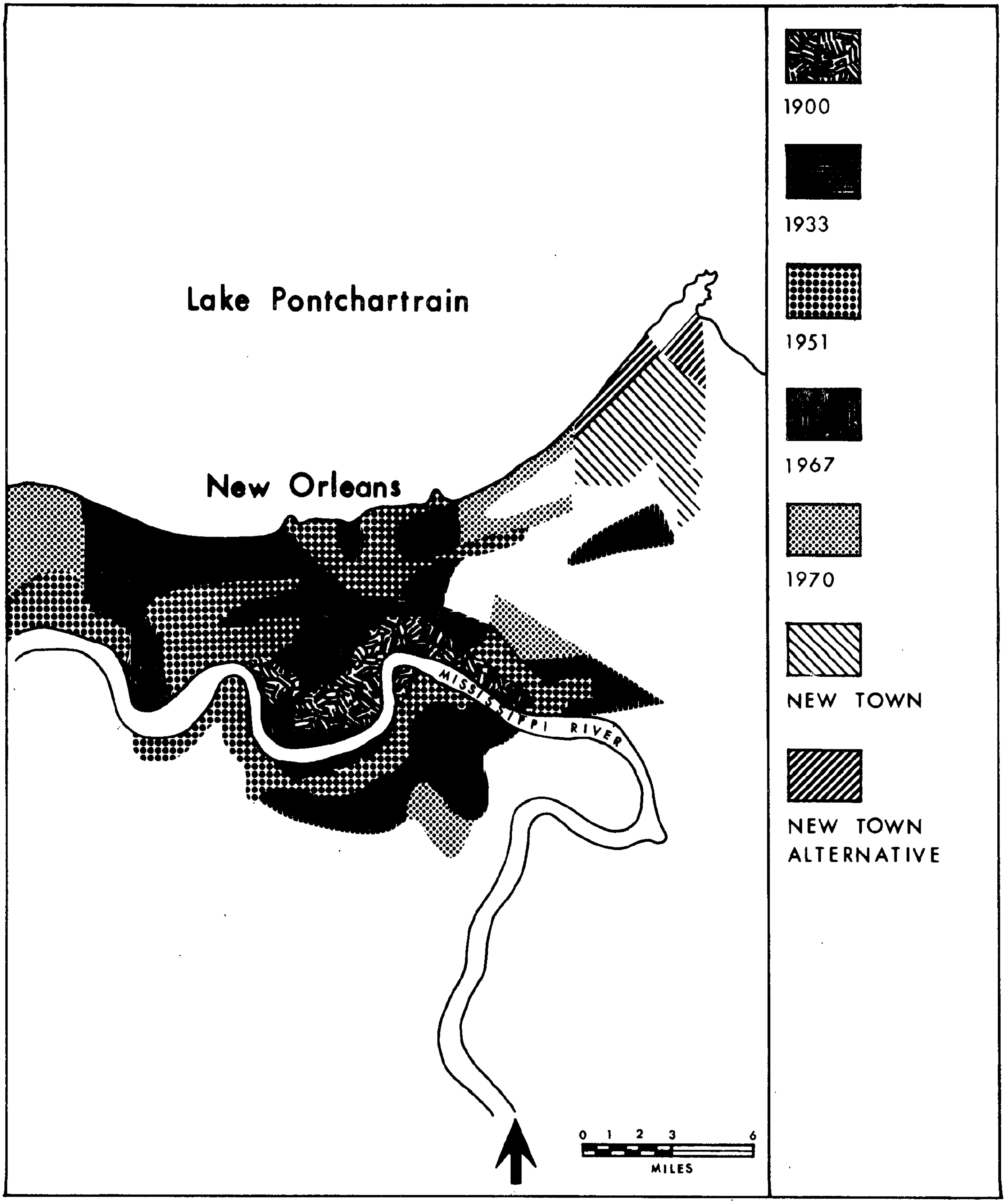


Figure 10. Patterns of urban development in the Greater New Orleans area, 1900-present.

When a backswamp area is drained, several factors operate to reduce land level. Initially, through shrinkage and oxidation of organic matter, the surface is lowered several feet. Reduction of pore pressure and consolidation can also cause reduction of the surface level. Fires are invariably started, accidently, or by eager hunters, which may burn stumps, wood particles, and even peat. Such fires have been known to smolder for months. The net effect is that the surface of the newly reclaimed land may be lowered 5 feet or more below sea level within a decade after drainage. If the drained area has ponds and small lakes, the effects may be even more drastic. The higher the compaction and settlement rate, the greater is the cost of drainage, flood control, and foundation engineering.

The reclamation history of a section of the city known as the Little Woods area is particularly interesting (Fig. 11, area A). As previously noted, reclamation work was first started in 1908. Within five years drainage canals, levees, and two pumping stations had been established (Fig. 12). The total area reclaimed from marshes along the south shore of Lake Pontchartrain amounted to 7,000 acres. Lots were sold by the New Orleans Lakeshore Land Co. in 5-acre plots with the idea that they would be planted in citrus orchards (Harrison, 1961). Sites were reserved for homes along the lake front, and space for commercial development was designated in a "town center." Even a park was included in the original plan. Purchase of a 5-acre agricultural plot carried title to a 40- x 100-foot "villa site" in the residential reserve. Okey (1918) reported that the land was bought as fast as it was drained, and, by 1916, 6,000 acres had been planted in corn or truck crops.

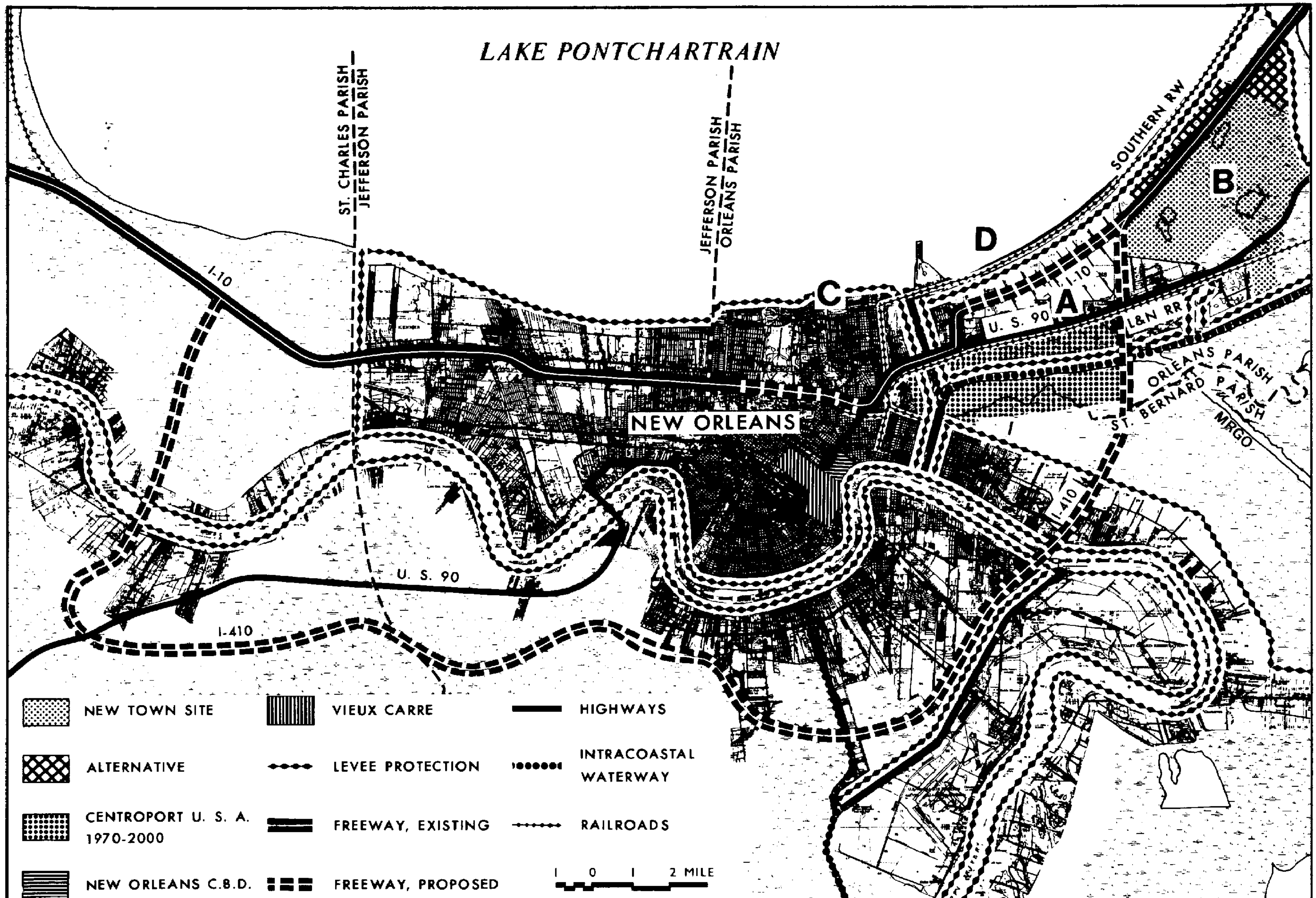


Figure 11. The Greater New Orleans Area.

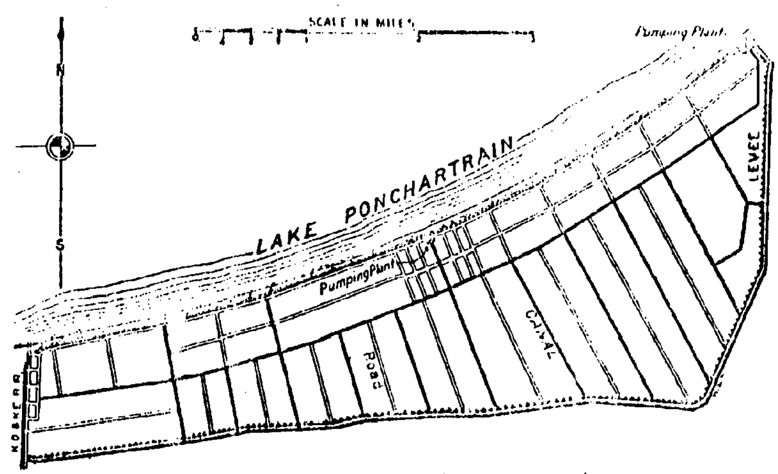


Figure 12. Sketch map of New Orleans Lake Shore Land Company tract.

The project eventually failed as an agricultural undertaking and the land was bought by speculators. For many years the tract remained largely undeveloped. During the last decade, however, with the construction of the Interstate 10 highway through the center of the tract, the speculator's dream has finally been realized, and the area is presently undergoing rapid urbanization.

A classic example of backswamp drainage under the most adverse natural conditions can be found in a project currently in progress in the eastern end of Orleans Parish. This land (Fig. 11, area B) was known for many years as the Michoud Plantation Tract and later as New Orleans East. A thin, branching system of distributary natural levee ridges and a few remnant beach ridges comprise the only high ground. Most of the area was, until very recently, covered by marshes and ponds. Largely through the efforts of local interests and the Orleans Parish Levee Board and the U.S. Army Corps of Engineers, the area has been surrounded by levees, and, as a result of a cooperative effort between the landowners and the City of New Orleans, has been partially drained. More recently, the Corps of Engineers has been involved in improvements of the existing system.

Both draglines and suction dredges were used in canal and levee construction. The suction or hydraulic dredge technique is most effective because it makes possible the utilization of shallow localized sands and clay bodies, such as old natural levee and beach deposits. Materials excavated by dredge can be transported for considerable distances in slurry form through the dredge tail pipe and discharged at the point of levee construction.

Plans for use of the 32,090-acre New Orleans East tract were made well in advance by the property owners. In 1959 a general plan was devised by Harland Bartholomew and Associates which designated 5,500 acres for residential development, 8,875 acres for commercial and industrial sites, and 2,000 acres for waterfront home sites. Projected population was 150,000, and a completion date of 1980 was projected.

Progress has been considerably slower than anticipated. Partial completion of Interstate 10 through the center of the property, completion of the Mississippi River Gulf Outlet to the south, partial completion of hurricane-protection levees around a large part of the tract, the proposed Interstate 410, the proposed Centroport U.S.A. (new port complex), and a proposed regional air carrier airport immediately east of the property have all enhanced the strategic location and value of the tract. Yet, after 13 years only a very small part of the Harland Bartholomew plan has materialized.

Early in 1972 New Orleans East, Inc., commissioned a new evaluation of the property. Social, economic, engineering, environmental, and planning consultants were engaged to explore the feasibility of a new community for the New Orleans East tract. The studies have resulted in a new comprehensive development design. On the basis of this document, the property owners, working in conjunction with city officials, have initiated a request for Housing and Urban Development (HUD) funding for planning and development of a new community.

The proposed new town would occupy 8,400 acres and have a projected year 2000 population of 85,000. Title to the 8,400 acres will be transferred to the city or its appropriate designee, but New Orleans

East, Inc., will retain title to the remainder of the 32,090-acre tract. A master plan for the entire site will be included in the HUD proposal.

The Pontchartrain New Town-in-Town Plan represents a substantial improvement over the 1959 General Plan New Orleans East. Foundation problems are identified and dealt with in a more realistic way. The environmental impact of the project is clearly outlined, and a plan for conservation of large areas of marsh, swamp, and natural levee forest and archeological sites as open space/recreation areas has been included.

At this point in time, given our present value system, existing legal structure, and the strategic location of this property, development seems inevitable. Present trends are toward conventional reclamation and development. If these trends continue, the entire 32,090-acre tract will ultimately be consumed by urban encroachment, with all associated social burdens and environmental stresses. The new community development offers a unique opportunity to focus and direct development in such a way that the needs of the growing city are satisfied while unique bits of the landscape are preserved and even enhanced. The project could become a model that would demonstrate that multiuse development of coastal wetlands is truly possible. Such an approach would do the following:

1. Demonstrate compatibility of development and conservation in coastal wetlands;
2. Minimize stresses on most beautiful and productive parts of the environment;

3. Compensate for environmental stresses by enhancing and optimizing natural environments and biological productivity in preserved open-space areas;
4. Serve as an educational device to demonstrate that wetlands are not wastelands but rather are very beautiful and highly productive environments;
5. Establish the limit of eastern expansion of the city;
6. Result in a totally unique community with many amenities;

Another type of reclamation involves filling of shallow nearshore zones of Lake Pontchartrain. Flood protection works along the south shore of the lake were initiated in the early 1900's when the Orleans Levee Board constructed levees some 300 or 400 feet from the water's edge along part of the lakeshore to prevent flooding during storms. Constructed of locally available material, often high in humus content, the levees were prone to shrinkage, burning, and subsidence. Because of the continuing flood threat, between 1873 and 1924 various studies were authorized and plans generated for improvement of the lake front. In 1924, under the direction of Colonel Marcel Garsaud, Chief Engineer of the Orleans Levee Board, plans were drawn for reclamation and improvement of the shore of the lake along an 11-mile frontage (McNamara, 1969). In 1926 pumping of hydraulic fill was initiated to create more than 2,000 acres of new high land in an area of marshes, swamps, and lake bottom.

Presently 6 1/2 miles of the project have been completed, including the New Orleans Lakefront Airport (Fig. 11, area C). The project has been described as a multiuse development providing flood and erosion prevention as well as recreation, residential, and public facility sites. Included are a lakeside public park 5 miles in length and averaging 500 feet in width; four of the finest residential subdivisions in the city; three bathing beaches; small boat-launching facilities; two sites for Louisiana State University in New Orleans; a site for the Gulf South Research Institute; sites for the Navy, Marine, and Army reserve training centers; and the general-aviation airport for the Metropolitan New Orleans area. This one-time lake bottom presently comprises one of the prime residential and recreational areas of New Orleans. Land reclaimed in this manner is far more desirable from the standpoint of engineering characteristics and flood control than drained backswamp. The fill derived from the lake bottom provides stable foundations, and the new land has elevations from 8 to 14 feet above sea level.

Plans for continuation of this lakeshore reclamation were made public by the Levee Board several years ago (Dixie, 1963; McNamara, 1969). The proposed extension (Fig. 13) involves construction of approximately 7 miles of seawall and the placing of 125 million cubic yards of hydraulic fill to reclaim an additional 3,381 acres. Land use will include the following: parks, parkways, and marina, 1,016 acres; single-family residential, 1,394 acres; garden apartments and high-rise apartments, 196 acres; commercial, 142 acres; schools and churches, 59 acres; streets and railroad rights-of-way, 574 acres. Costs of the entire project were estimated in 1969 at $218 million (including streets, drainage, sewerage, water, miscellaneous utilities, and landscaping).

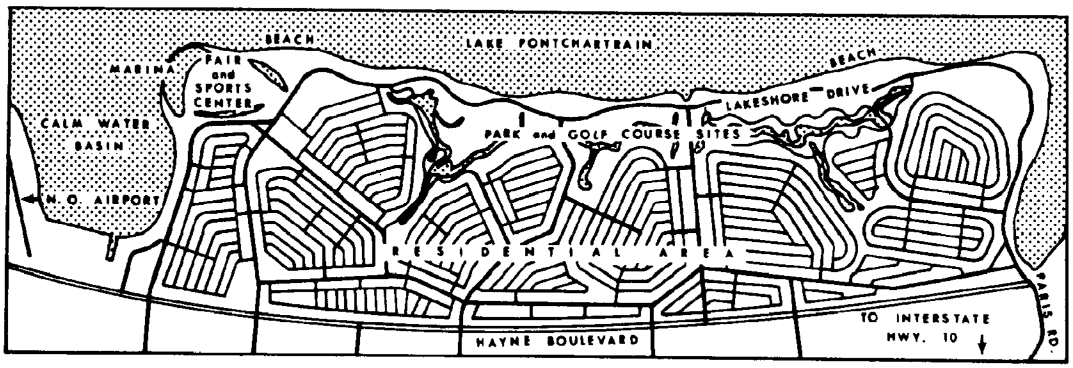


Figure 13. Proposed land reclamation along the southern shore of Lake Pontchartrain in the vicinity of Little Woods, La.

Increases in population and industrial development have forced New Orleans to expand into areas that become more and more difficult to develop and maintain. While natural levee ridges can be easily protected by dikes or artificial levees from both river floods and storm-induced tides, the protection of drained flood basins is more complicated. The level of river floods may stand as much as 20 feet above the drained flood basin surfaces, and storm-generated tides may be as high or higher (Fig. 14). Hurricanes Betsy (1965) and Camille (1969), both of which inundated large areas of drained flood basin in New Orleans, provided ample proof of the possible undesirable nature of reclaimed marsh and swamp land for urban development.

Substantial measures have been taken to prevent recurrence of similar disasters. As indicated in Figure 15, an extensive system of levees and drainage structures comprises the comprehensive hurricane-protection plan of the Greater New Orleans area (U.S. Army Corps of Engineers, 1971). Combined levee and drainage structures have been completed, or are in the planning or construction stages, at various locations along the shores of lakes Pontchartrain and Borgne. Likewise, floodwalls and levees along the Mississippi River Gulf Outlet, along the Inner Harbor Navigation Canal, and in the Chalmette area are presently under construction, and many reaches have already been completed.

The overall plan includes flood-control structures designed to prevent entry of hurricane tides into Lake Pontchartrain. This will be accomplished by construction of a barrier across the eastern end of the lake. Included are a gated control structure, navigation locks,

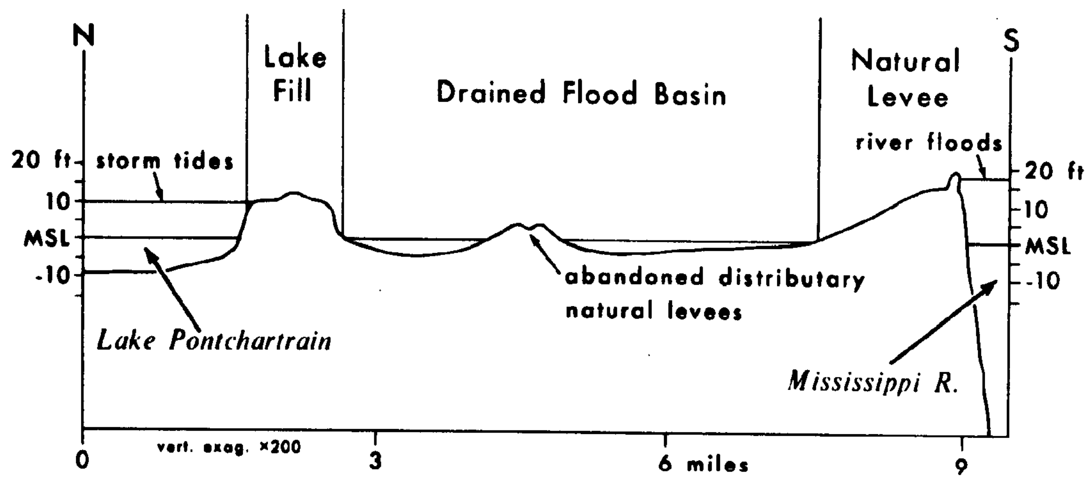


Figure 14. Profile through the New Orleans area showing relative elevations of surface features and extreme flood and tide levels.

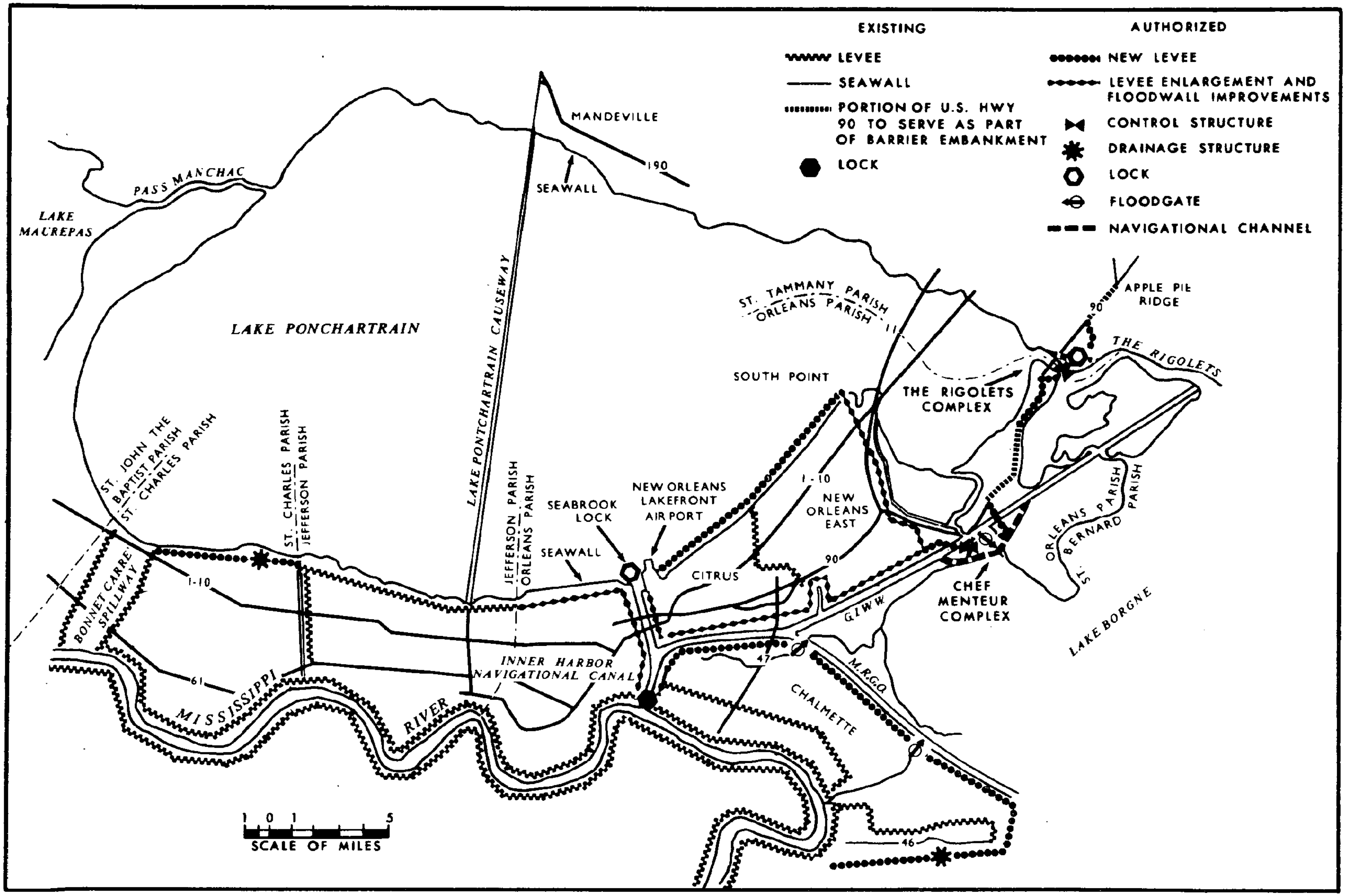


Figure 15. Lake Pontchartrain and vicinity hurricane protection. (After U.S. Army Corps of Engineers, 1971).

approach channels, closure dams, and adjoining barrier levees at the Rigolets. A gated control structure and channels, navigable floodway and approach channels, relocation of the Gulf Intracoastal Waterway, and a closure dam and adjoining barrier levees at Chef Menteur Pass are also planned. The third important link in the barrier is a lock and gated control structure at the lakeward terminus of the Inner Harbor Navigation Canal in the vicinity of Seabrook. Completion of these structures will make it possible to effectively close off Lake Pontchartrain from rising tidal waters generated by approaching storms.

New Reclamation Projects and Developments in Southeastern Louisiana

Southeastern Louisiana is experiencing a new wave of land reclamation that may rival the 1915-1920 period. Active and proposed reclamation schemes related to industrial sites, nuclear power plant locations, planned communities, recreation complexes (harbor towns and fishing resorts), airports, and Florida-type waterfront communities are appearing at an alarming rate. Major reclamation projects in the planning or development stage include:

17.* Venetian Isles is a Florida-type project of New Orleans East, Inc. located in the marshes near Chef Menteur Pass, Orleans Parish. It features a branching canal network with spoil-bank ridges adjacent to the canals. Although outside of the hurricane protection levees, ridges in the development are about seven feet above mean gulf level. Storm surges from Hurricane Camille (1969) reached approximately eight feet in the area, but presumably recurrence of such high tides will be prevented upon completion of the east Pontchartrain barrier

* Map reference, Figure 4.

and control structures.

18. Eden Isles, another Florida-type development, is located in the marshes on the north shore of Lake Pontchartrain near Slidell, La. The area was originally drained and reclaimed for agriculture in the early 1900's, but the project failed and the old fields were flooded. An intricate network of canals has already been dredged and homesites are being sold on spoil bank ridges adjacent to the canals. As shown in Figure 16, the total project encompasses 2,400 acres with 35 miles of navigable waterways having minimum depths of 30 feet by 140 feet wide. Eden Isles is billed as a complete community with a commercial zone, school sites, and community park areas in addition to home sites.

19. Pontchartrain New Town-in-Town and New Orleans East ultimately involve a 32,090 acre tract of wetlands (Fig. 17). As previously discussed, the proposed new community will serve as the focal point for development of the tract. Projected population for the new community is 80,000. In regard to use of the wetlands, the plan can best be described as innovative. Large tracts of marsh, swamp, and natural levee forests have been designated for management as open space, recreation, and renewable resource areas. A Human Resources Services Corporation will be responsible for the ongoing processes of planning and development. A new approach to foundation and drainage problems has been proposed which will utilize sand from buried barrier island deposits underlying the site as a source for fill for building

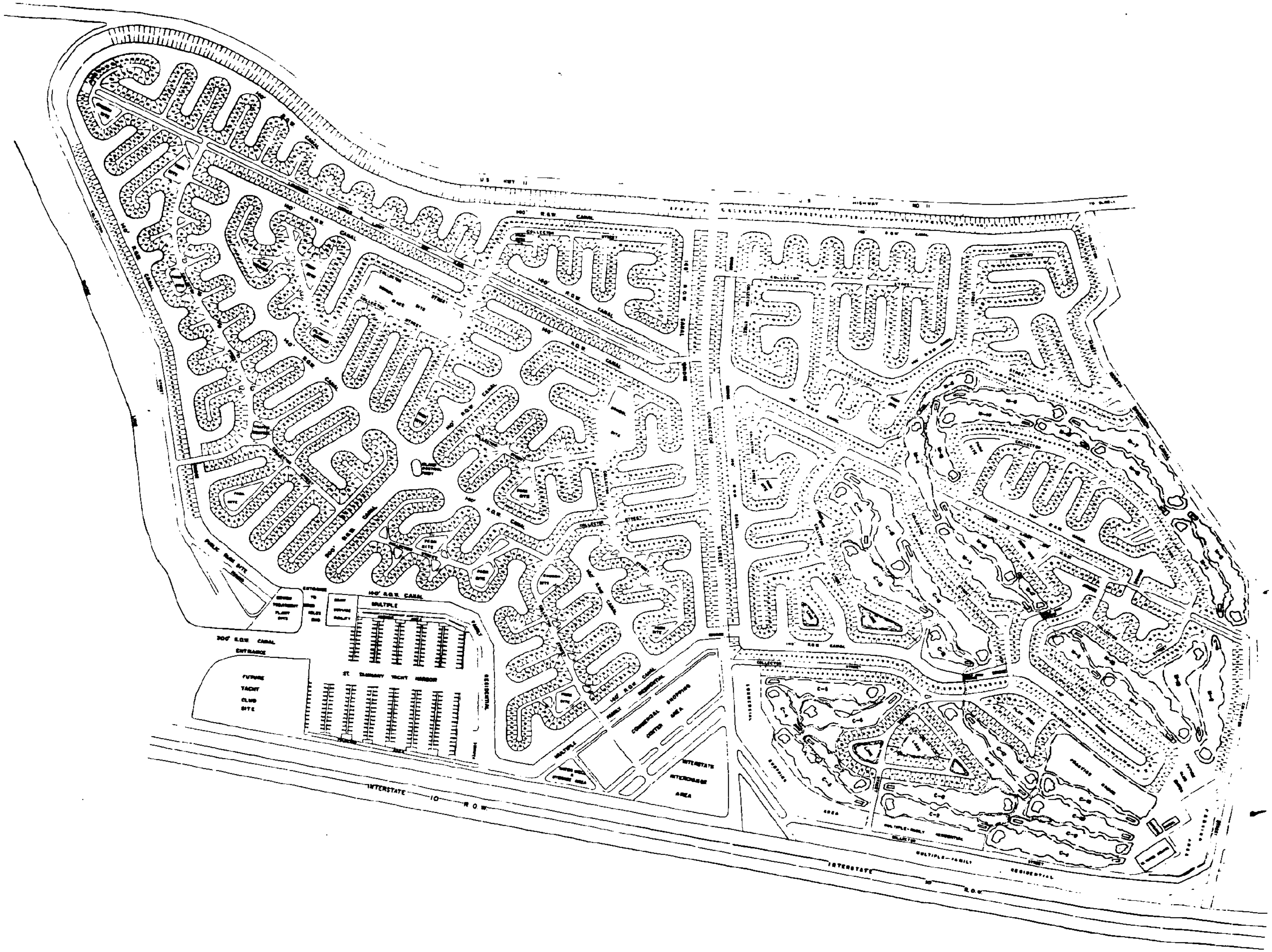


Figure 16. Eden Isles, a Florida-type development located on the north shore of Lake Pontchartrain.

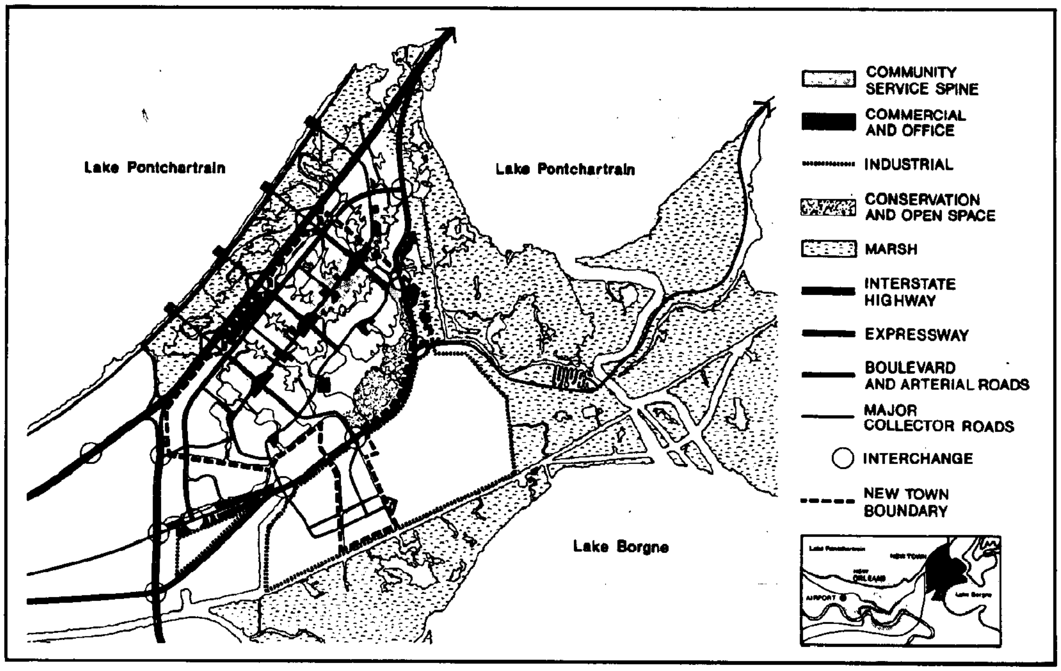


Figure 17. Pontchartrain New Town-in-Town and New Orleans East involving 32,090 acres of wetlands.

ridges which will serve as the topographic spine of the new community. This will allow water in canals, lakes, marshes, and swamps to remain at present natural levels. The most important aspect of the whole project is that environmental factors were of major concern to the planners and some attempt has been made to minimize the environmental impact of the development while utilizing certain unique environmental opportunities as amenities for future residents.

20. Centroport, U.S.A. will constitute a major new port facility for the New Orleans area. The site consists of approximately 2000 acres of undeveloped marsh and swamp along the Intracoastal Waterway at its intersection with the Industrial Canal. Deteriorating, out-of-date facilities of the present port complex along the Mississippi River have been cited as the main reason for the construction of the new port. The Centroport will relocate existing and newer facilities in a setting where they will be able to interact directly with more adequate transportation networks, utilize sufficient land areas, and merge with newer, adaptable facilities vital to an efficient port. The location is directly linked to the Mississippi River-Gulf Outlet, with a present authorized navigation depth of 35 feet. A proposed ship canal and lock between the Mississippi River and the Mississippi River-Gulf Outlet would not only alleviate barge congestion in the existing Industrial Canal locks, but would also serve the new

Centroport. A number of environmental problems are associated with Centroport. Foundation conditions are extremely poor at the site. Near surface peat deposits are as much as 16 feet thick, among the thickest in the greater New Orleans area. Pollution from cargo spillage presents a threat to the Lake Borgne wildlife and fisheries. The proposed Mississippi River-Mississippi River-Gulf Outlet ship canal and lock is being opposed by local government agencies and conservation groups on the grounds of environmental damage related to dredging, spoil disposal, and changes in hydrology of the region.

21. The Jones Island project is a proposed 3000 acre development on a large swamp island bounded by Lake Pontchartrain, Lake Maurepas, North Pass, and Pass Manchac. A joint venture of the Jones Island Development Corporation and the Walker Land Company, the project is scheduled to include 4,000 new home sites, waterfront sites, a motel and marina, apartments, new water channels, and a man-made lake and shopping center.

22. The Labranch area was originally developed for agriculture in the early 1900's by Mr. Edward Wisner and his associates in the Louisiana Meadows Company and affiliated organizations. For a short period it was a successful agricultural undertaking, but subsequently it failed and the fields became flooded. Resulting ponds have been a favorite hunting and fishing area for many years. The recently opened Interstate 10 link between Laplace and Kenner, La. traverses the ponds, which have partially reverted to a natural condition. The elevated roadway over the ponds with their fringing marshes and cypress swamps is

one of the most beautiful highways in the state, providing a spectacular entranceway into the city from the west. A drive along this stretch of highway should be enough to convince most observers of the aesthetic and recreation values of wetlands environments. An interchange planned for the center will connect I-10 with the proposed I-410 to the south. This highway will cross the Mississippi River near Luling, La. and loop south of New Orleans on the west bank of the river. A flood protection levee authorized along the lakeshore in this area between the Jefferson-St. Charles Parish line and the east levee of the Bonne-Carre Floodway will make drainage economically feasible. This, coupled with the strategic intersection of the two interstate highways, makes the area a prime target for development. A major street plan has already been outlined by the parish, and real estate speculation is booming.

23. Possible development of a new community on a large tract of land in St. James Parish has already been announced. The tract, known as the Lutcher-Moore Property, lies in the fresh water swamps south of Lake Maurepas, and includes most of the drainage area of Blind River. The total acreage of the area and projected plans are not known at this time.

24. A site selection study for a new air carrier airport to serve the New Orleans region favored a location in the eastern end of Lake Pontchartrain (Spears Associates, et. al., 1970). The airport runways, terminal, and related facilites would be built in the lake. Three approaches have been proposed for

construction: (1) an artificial island, (2) a raised platform, or (3) in a poldered area on the lake bottom. The gross land requirements for the ultimate development are estimated to be 13, 500 acres (included in this figure is a 4,000 acre noise buffer zone and 200 acres of commercial and supplementary development). Two alternate sites are still under consideration. One of these is in the fresh water swamp area west of Lake Pontchartrain and north of Laplace, La. in St. John the Baptist Parish. The second alternate, favored by the consultants, is located north of Lacombe, northeast of Mandeville between Covington and Slidell in St. Tammany Parish.

25. Alligator Point, a marshy peninsula extending into Lake Borgne, is under consideration by the New Orleans Public Service, Incorporated, as a possible site for a nuclear power plant. Details of this proposal are not available at this time.

As indicated by the preceding review, land reclamation presents one of the greatest threats to the wetlands of Louisiana's estuarine zone. Perret _et al_ (1971) have measured 116.3 miles^2 of filled and drained areas in coastal Louisiana (see Table 3). The total acreage of reclaimed wetlands is increasing rapidly.

Drainage Canals

Related to the problem of land reclamation is the improvement of drainage in the upper fresh water ends of estuarine basins. Previous studies have emphasized that each estuarine basin is a complex hydrologic system, and that fresh water runoff and storage characteristics of the upper ends of the system are critical factors in determining salinity and

Table 3

Filled and Drained Areas in Coastal Louisiana, 1969 (After Perret et al, 1971)

	Total acreage of coastal Louisiana study area	Spoil banks** (Pipeline canals and small canals)	Emergent Spoil banks*	Drained marsh*	Other*	Total*
acres	3,695,700 (land) 3,378,924 (water)	40,000	25,369	47,792	1,246	74,407
$miles^2$	5,774.5 (land) 5,279.6 (water)	62.5	39.6	74.7	2.0	116.3

* Represents only major filled areas.

** Estimated from measurements of canal lengths.

other characteristics of the water chemistry in the seaward ends. Under natural conditions, swamps, marshes, and lakes provide important natural storage areas for fresh water in the upper ends of the system. The sinuous nature of the backswamp stream network regulated the rate of runoff flowing into the brackish mixing zone of the system, and thus serve as a regulatory mechanism for the conservation of fresh runoff. In many of the coastal Louisiana basins there was a lag time of six months or more (under natural conditions) between rainfall in the upper ends of these basins and its effect on salinities and water chemistry parameters in the brackish zone. This served an important function since precipitation is not evenly distributed through the year. Consequently, during the dry months of the autumn and early winter this stored fresh water continued to trickle slowly seaward through the basin preventing drought and salt water intrusion.

Pressure for additional agricultural, urban, and industrial lands on backslopes of natural levees and in the upper fresh water ends of the basins has resulted in attempts to improve drainage. Typical of such plans is the Bayou Chevreuil flood control project of the Des Allemands Barataria estuarine basin (Figure 18). As originally proposed, the project was a cooperative federal-local venture, U.S. Army Corps of Engineers participation being authorized by the Flood Control Act of 3 July 1958. More recently the project has been de-authorized. Nevertheless it warrants some consideration, as it illustrates problems related to backswamp drainage.

The project plan provided for enlargement and realignment of Bayous Chevreuil, Citamon, and Verret from Lac Des Allemands to the vicinity of Donaldsonville, La., a distance of 32.4 miles, as the major drainage out-

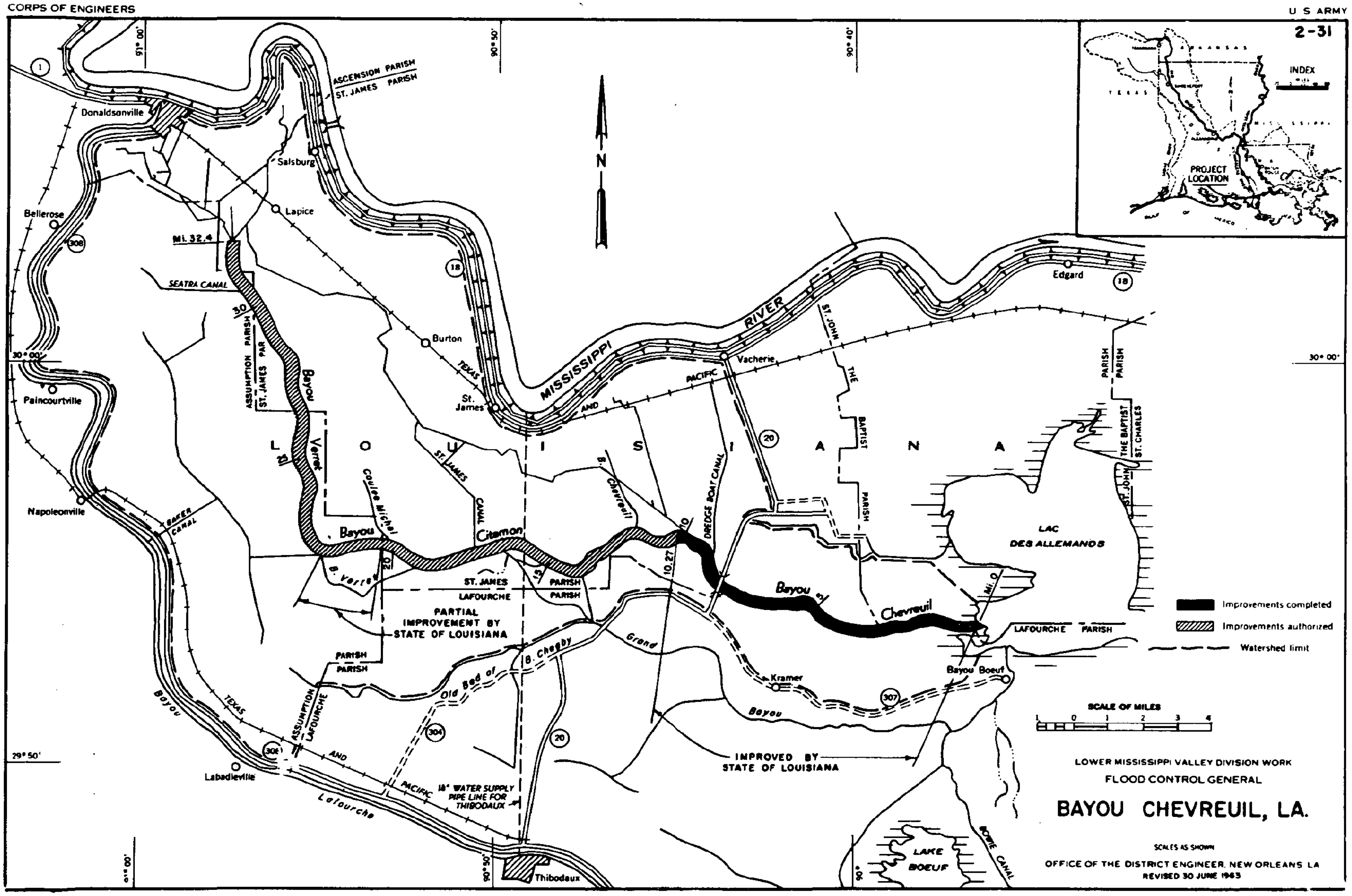


Figure 18. Bayou Chevreuil flood control project of the Des Allemands Barataria estuarine basin.

let. Improvement of lateral drainage was included as a part of the local participation. The immediate effect of this project, if completed, would be to increase the rate of runoff from this segment of the Des Allemands-Barataria estuarine basin, lower water levels in the surrounding swamps and waterways. Secondary effects would be to alter the vegetation in the swamps, reduce fresh water storage capacity and lag time for the entire basin, resulting in a possible increase in salt water intrusion in the lower ends of the basin south of the Gulf Intracoastal Waterway during dry periods. This, in turn, should alter both fauna and flora in the lower ends of the estuarine system. Resulting floral changes in the brackish zone could cause marsh deterioration and accelerate land loss. In short, this project would have altered the hydrologic balance and water chemistry of the Des Allemands-Barataria basin and may have caused some serious environmental repercussions.

NAVIGATION CANALS

Coastal Louisiana has the greatest number of inland waterways of any state in the Union (Fig. 19). The Gulf Intracoastal Waterway (GIWW) traversing the coastal zone in an east-west direction runs from Florida to Brownsville, Texas. Numerous trans-coastal waterways extend south like spokes connecting the GIWW and the Gulf. Extensive navigational improvements have been made to natural waterways. They have been straightened, widened, and deepened. The mouths of most streams have been dredged and/or jettied and the outlets of virtually every lake of consequence have been improved for navigation. In a number of instances, navigation canals have been relocated to shorten their length, leaving the old routes abandoned as linear lakes. Periodically new canals are added to the system to develop new ports and as a convenience to navigation interest. While this network of canals is of unquestionable economic importance to Louisiana, the environmental costs have been very high and will continue to accrue. While it is beyond the scope of this report to consider every navigation channel in the Louisiana coastal zone, certain channels do illustrate environmental problems.

The GIWW cuts across the "hydrologic grain" of almost every major drainage basin in the coastal Louisiana area. The channel and its associated spoil tend to re-route runoff and circulation. In the Lake Borgne area it has probably caused salt water intrusion. Although the total impact of this canal is difficult to evaluate, it has caused major changes in the runoff and circulation patterns.

Many drainage and navigation canals have low spoil banks. These spoil banks restrict free water flow, and their construction affects

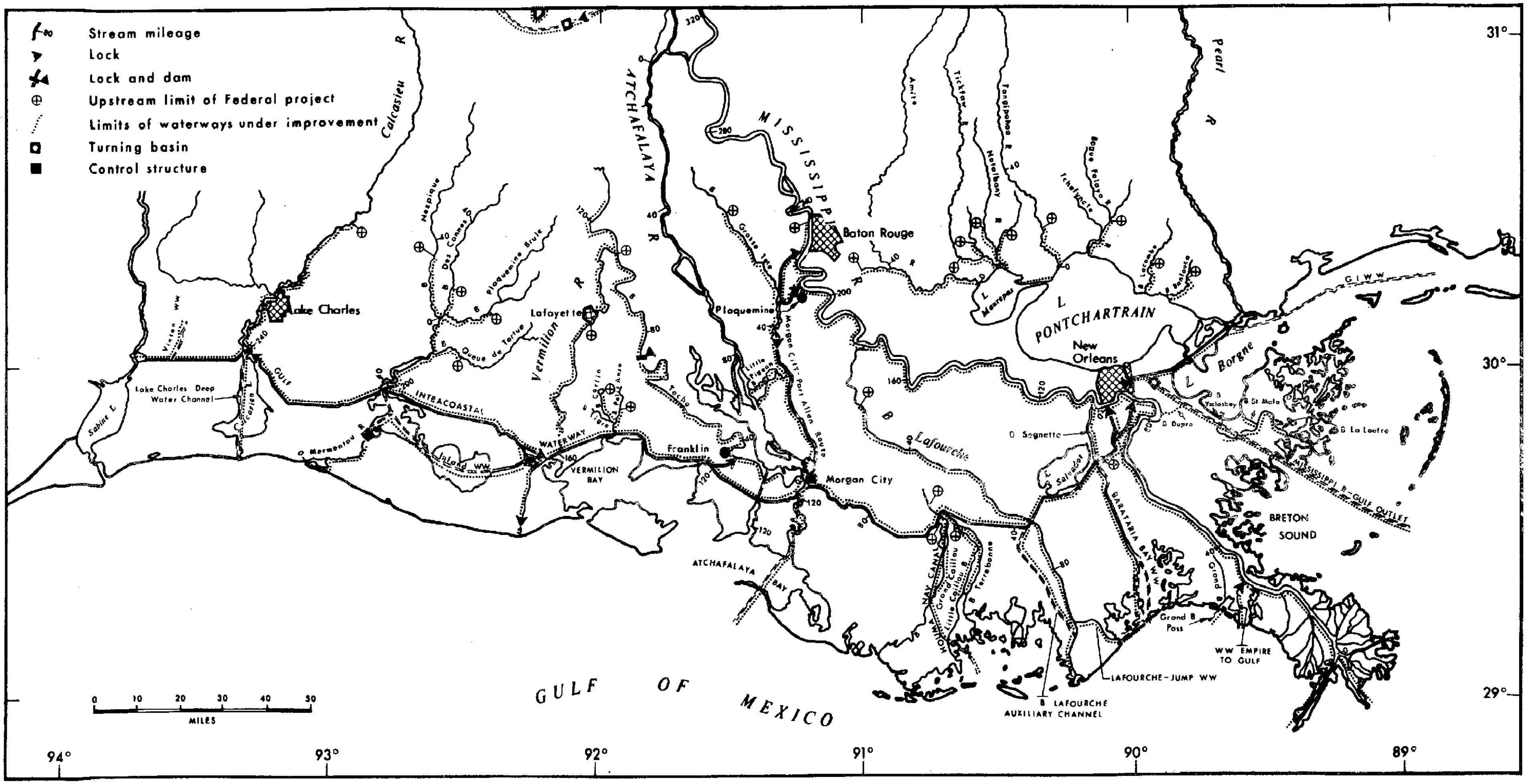


Figure 18. Navigation canals and locks in coastal Louisiana (After U.S. Army Corps of Engineers, 1968).

adjacent environments. The spoil banks become habitat types in themselves. Raised several feet above the surrounding water, they develop high ground vegetation types. Some that have been in existence for over 20 years have fine stands of oak and other large trees. Their potential use by wildlife and as a recreation base is high.

Of all navigation channels in coastal Louisiana, the Mississippi River-Gulf Outlet (Fig. 20) has probably had the greatest environmental impact. The channel was dredged in the late 1950's and early 1960's to an authorized width of 500 feet and depth of 35 feet. Construction of the channel destroyed 23,606 acres of marsh and shallow nursery areas--17,058 acres by spoil deposition and 6,548 acres by deepening (Rounsefell, 1964).

Secondary effects are equally serious. The channel has greatly altered the hydrology and water chemistry of the adjacent estuarine areas. The large cross-section of area provides an avenue of ingress and egress for runoff and tidal waters. Changes in salinity are well-documented. Recording stations in the vicinity of the channel show significant changes after the channel was opened (about 1959) and completed (1962) (see Figures 21-23).

Salt water intrusion is a major problem. Shown in Figure 24 is a pronounced salt water wedge which is usually present in the channel. Salinities in the vicinity of Paris Road have been more than doubled.

Numerous small tidal channels and canals connect the outlet with adjacent marsh areas (Fig. 25). Although detailed studies have not been conducted, dieback of oak trees along old natural levee ridges, dieback of marsh grass along tidal streams and enlargement of marsh ponds have

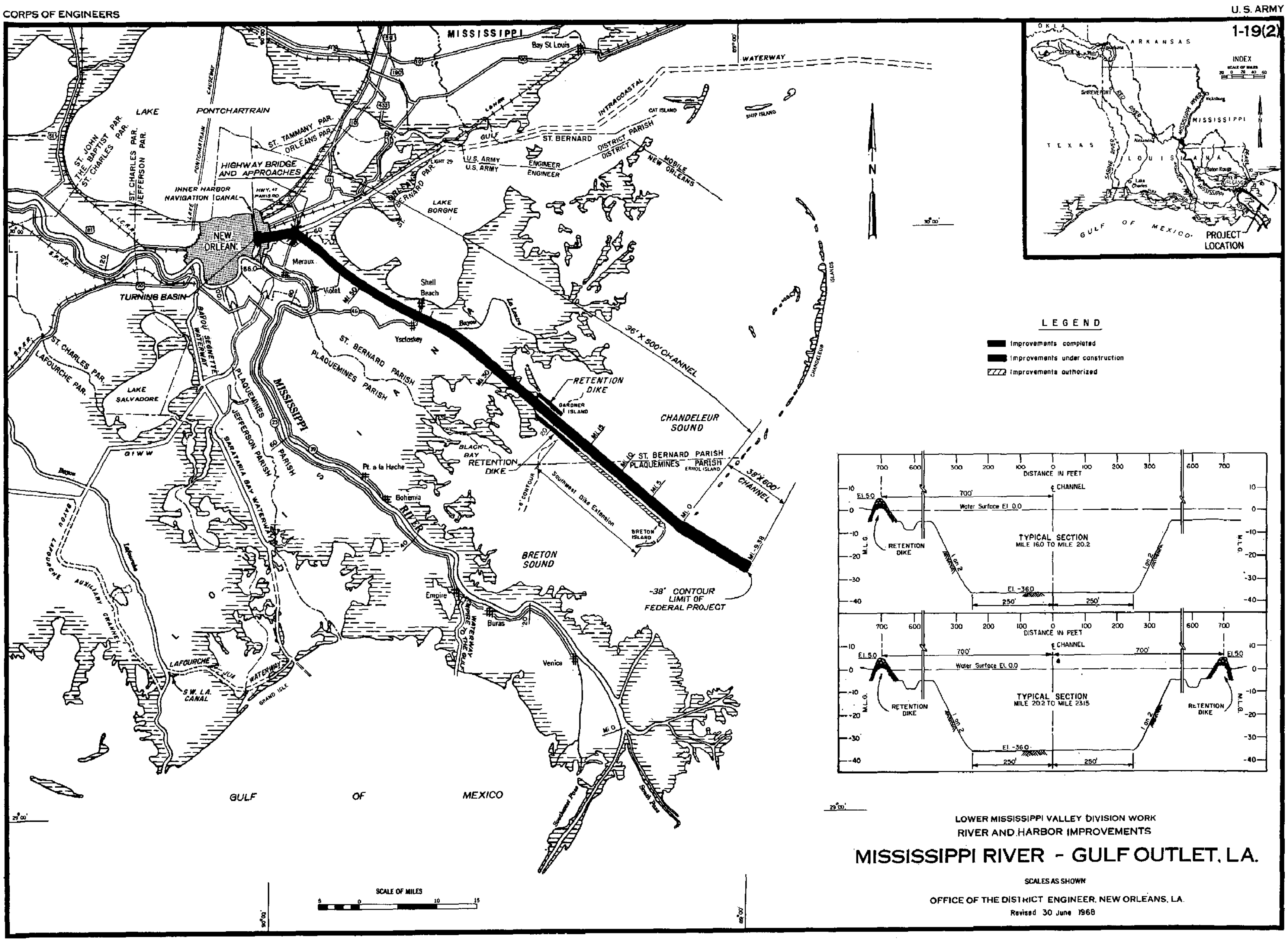
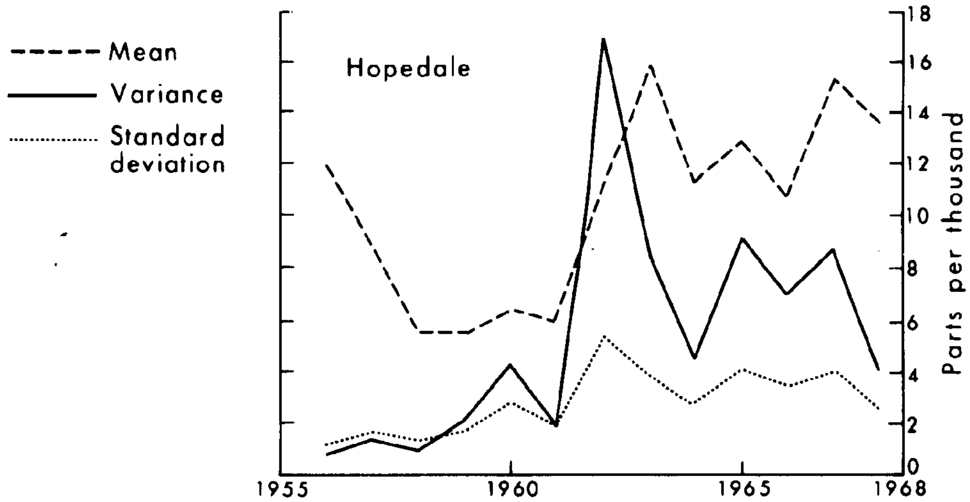


Figure 20. Mississippi River Gulf Outlet and vicinity. (After U.S. Army Corps of Engineers, 1968)



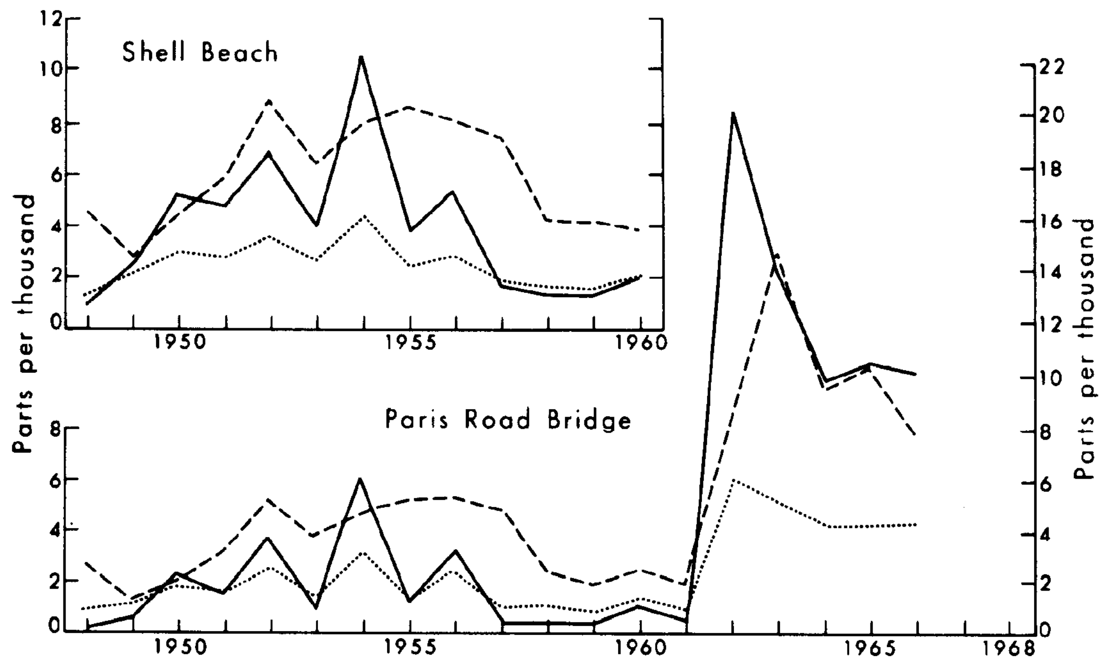


Figure 21. Salinity records from three stations in the study area and vicinity. Curves reduced from daily and bi-weekly measurements. Data from New Orleans District, U. S. Army Corps of Engineers.

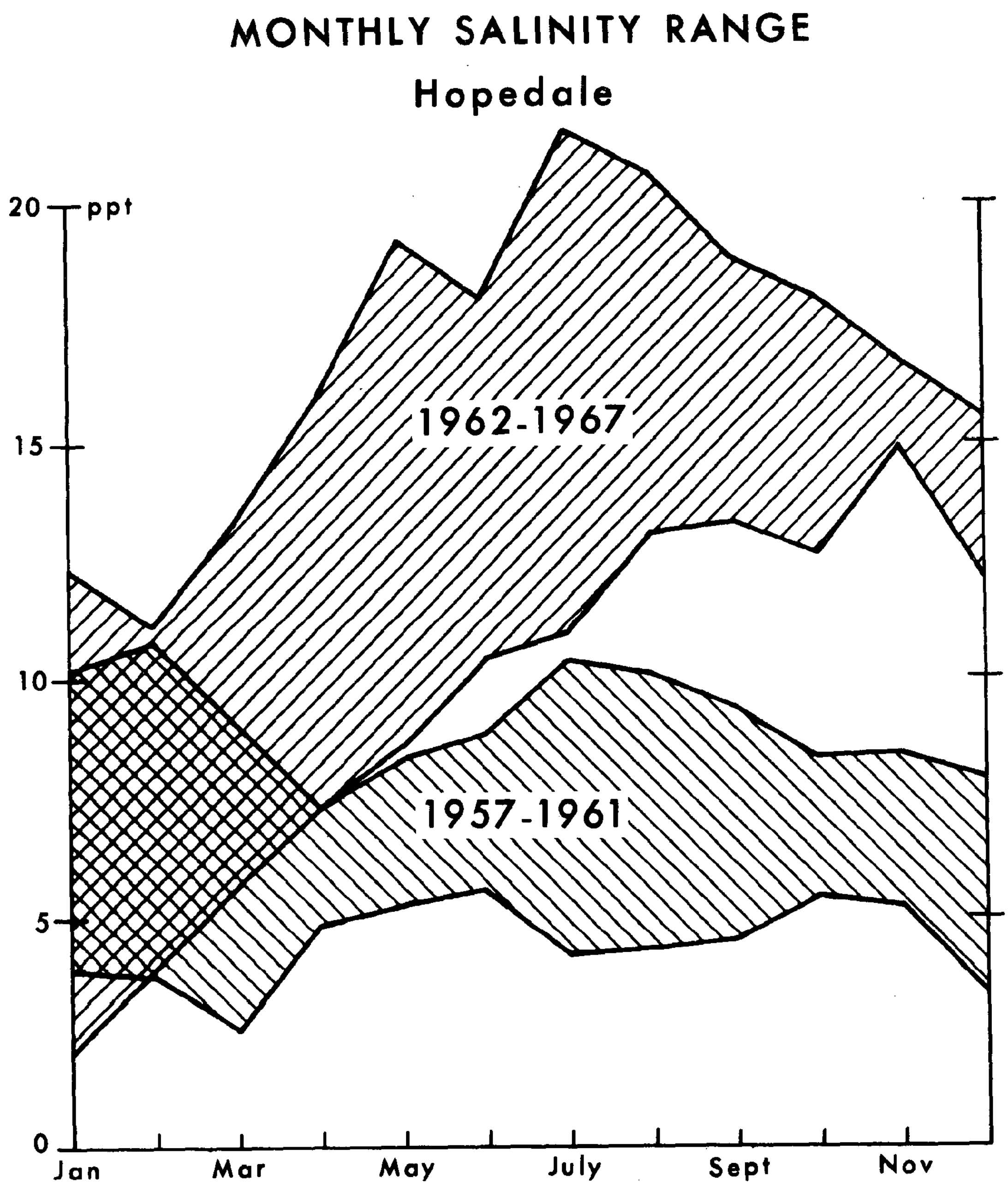


Fig. 22. Comparison of monthly salinity ranges at Hopedale for periods before and after construction of MRGO. Data from New Orleans District, U.S. Army Corps of Engineers.

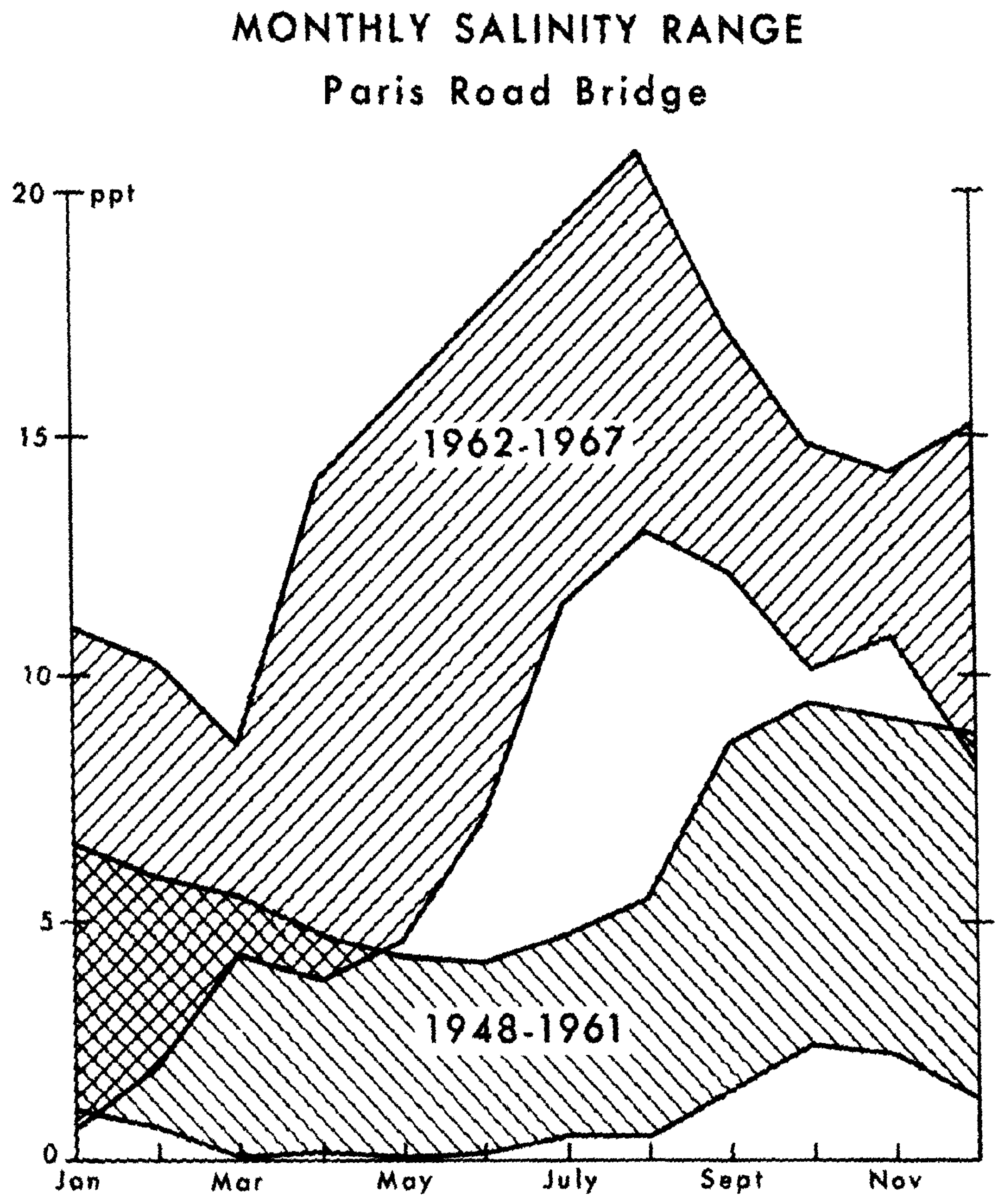


Fig. 23. Comparison of monthly salinity ranges at Paris Road Bridge for periods before and after construction of MRGO. Data from New Orleans District, U.S. Corps of Engineers.

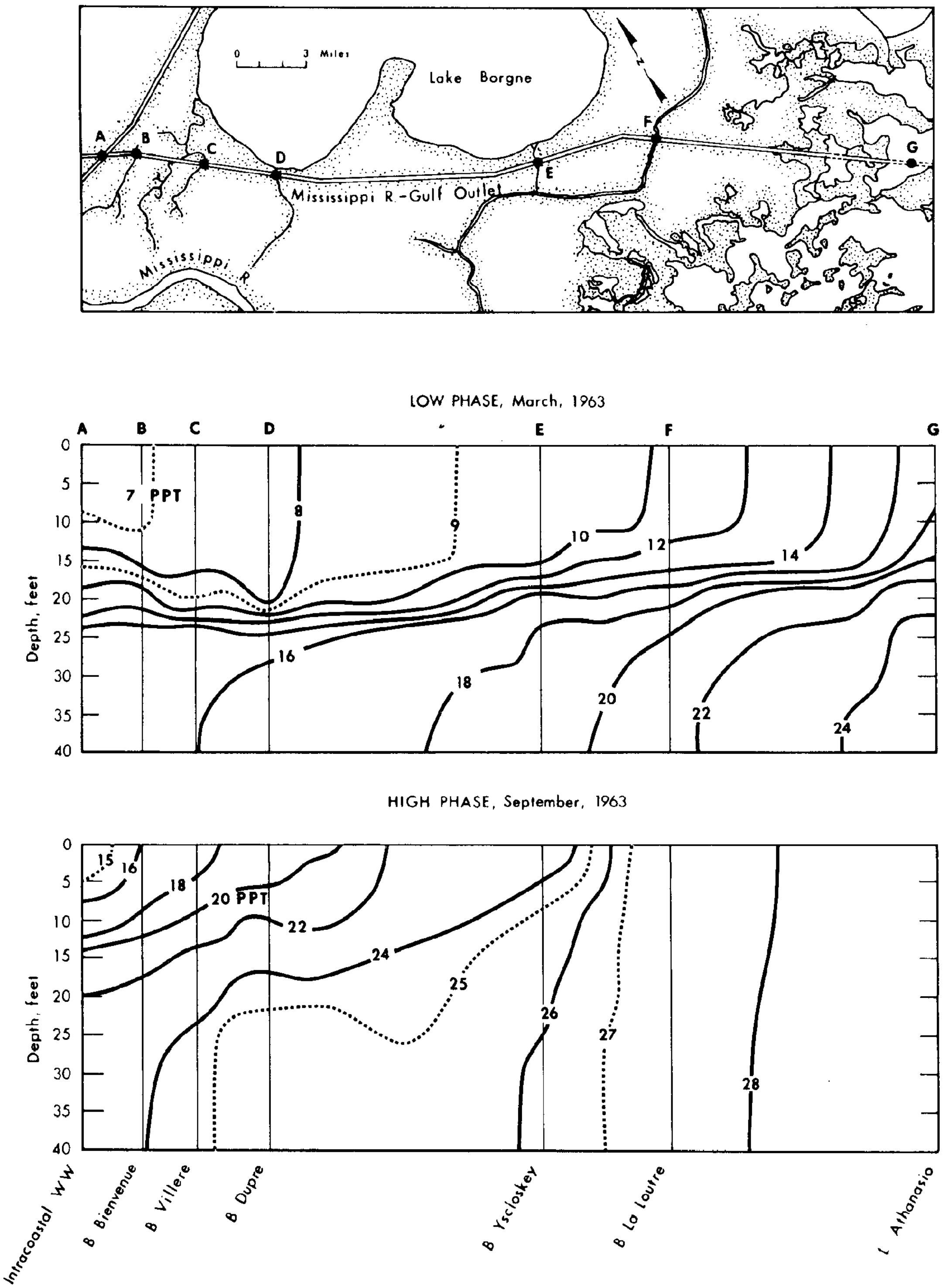
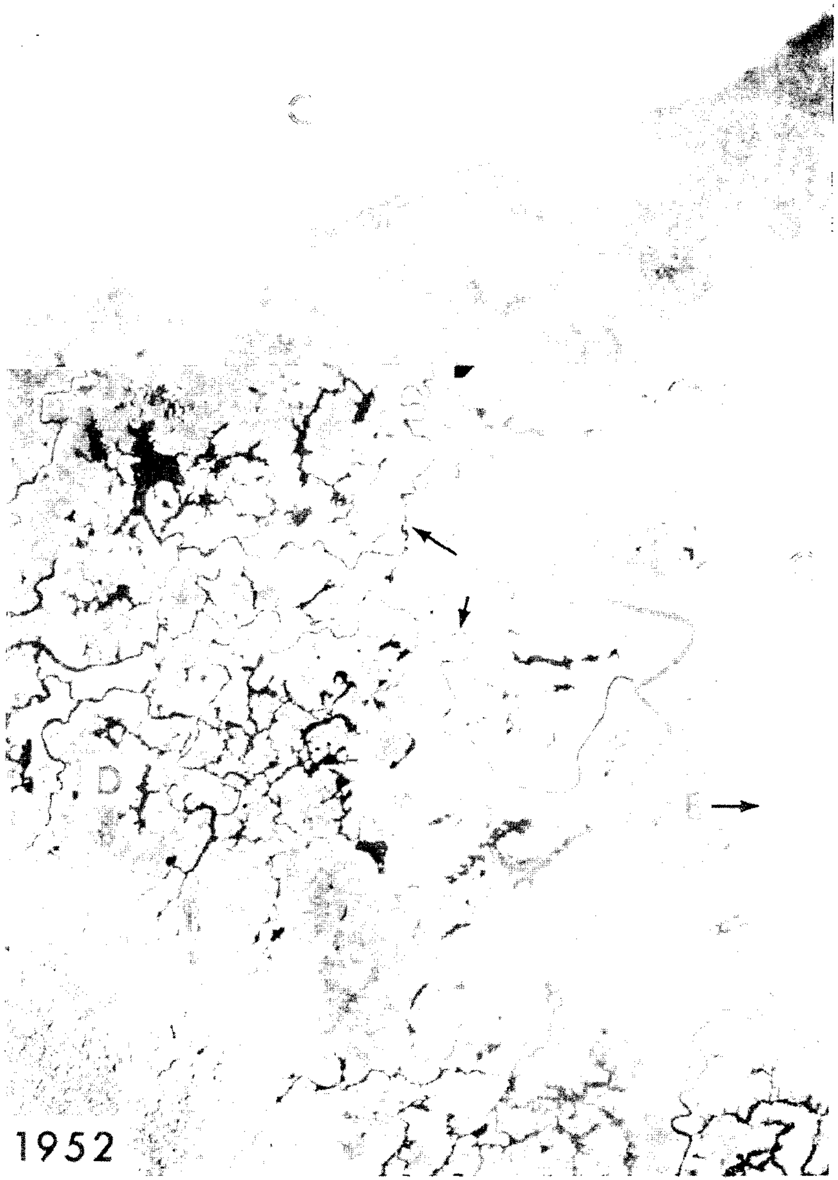
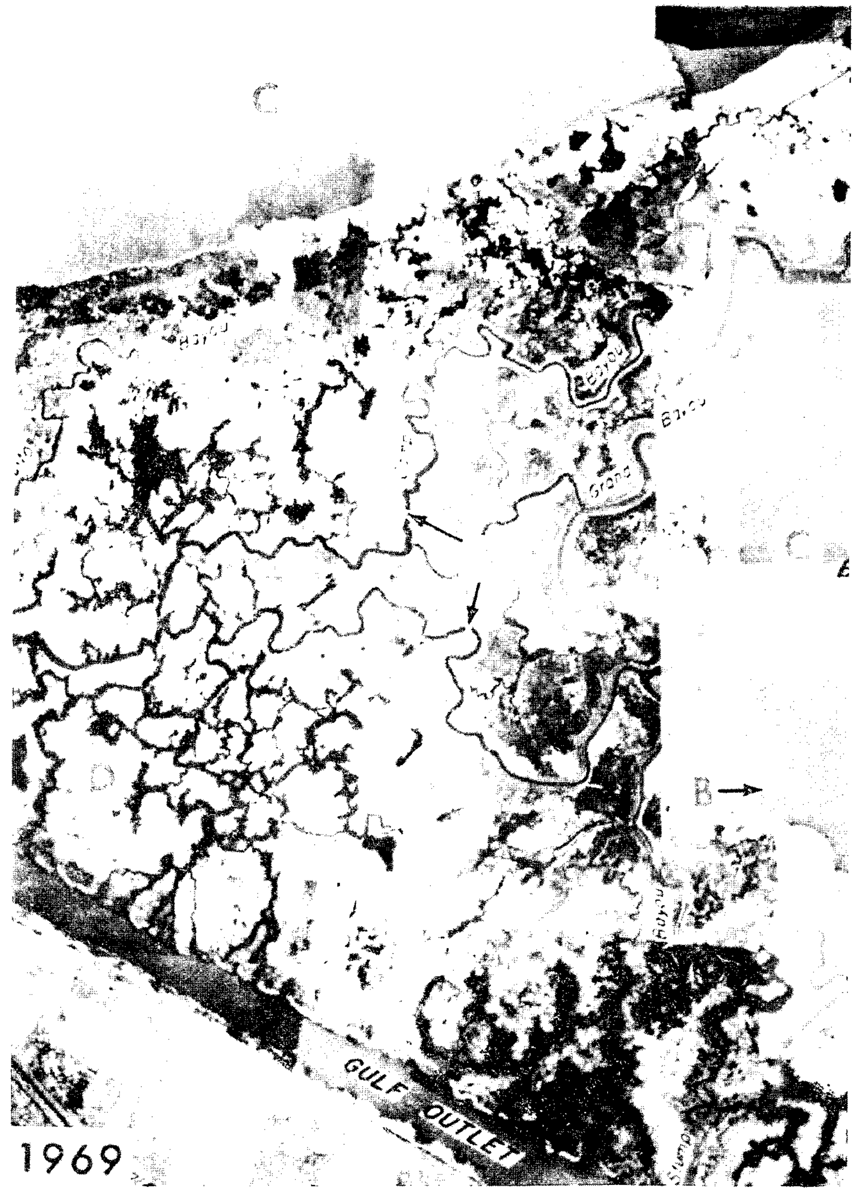


Figure 24. Vertical salinity structure in the MRGO. Note extreme salinities in the vicinity of Bayou Bienvenue during September, 1963, a period of low fresh water runoff. (after Amstutz, 1964).

Figure 25. Comparative aerial photographs of marshes in the vicinity of the Mississippi River-Gulf Outlet, St. Bernard Parish, Louisiana. In 1952, tidal streams serving the marsh area (A) were in adjustment to local runoff and the tidal regime of Lake Borgne (C). Retreat of the muddy lake shore is evident (B) and numerous small ponds (D) in the marsh suggest early stages of marsh deterioration. In the lower left hand corner of the photograph remnants of an old cypress swamp can be seen. We can infer from the photograph that in 1952 there was a probable salinity gradient from near fresh in the lower lefthand corner to brackish along the lakeshore. Completion of the Gulf Outlet greatly modified both runoff and salinity in this area. The spoil in the lower lefthand corner of the 1969 photograph forms a barrier to runoff. Water exchange from marsh ponds (D) is partially redirected into the Gulf Outlet instead of through bayous to Lake Borgne. The photo suggests some enlargement of marsh ponds that are connected with the Gulf Outlet. The Gulf Outlet reverses the previous salinity gradient, highest salinities now occur in the vicinity of the channel (formerly a fresh area) and decrease into the marsh. The scalloped edge of the outlet channel indicates massive bank slumping.


C
D
B
1952


C
D
B
Grand Bayou
GULF OUTLET
1969

been observed on recent field excursions and have most likely resulted from increased salinities. Conditions of marsh deterioration in some areas marginal to the channel can best be described as severe.

Foreshore erosion and bank slumpage along the canal banks are primarily a result of the thick sequence of poorly consolidated sediment through which the channel was excavated. Shoaling has been a recurring problem in the offshore reaches due to tidal action and storms. These conditions have resulted in a continuous and costly program of maintenance dredging. Undesirable effects of this dredging include increased turbidity and the impact on flora and fauna of spoil disposal.

Factors considered in the economic justification for the MRGO were reduction in turn around times and the need for additional wharfage in the Port of New Orleans. Traffic records of waterborne commerce indicate that only a small fraction of the total number of vessels and tonnage traveling between the Gulf and the Port of New Orleans utilize the MRGO. An overwhelming majority still use the Mississippi River. While the distance into the Port and the turn around time are reduced, the travel time is greater. The relatively narrow and shallow channel dictates substantial reductions in speed for safe navigation of large vessels.

The St. Bernard Parish Police Jury, the governing body of the parish in which most of the channel is located, has stated repeatedly that the project has failed to achieve economic projections. However, the project sponsor, the Board of Commissioners of the Port of New Orleans, trenchantly supports its viability. While an in-depth discussion of these opposing viewpoints is beyond the scope of this report, it seems appropriate to mention that more than a decade after its official opening, the channel is still highly controversial.

Because of sedimentation problems in the seaward end of the channel, it has been necessary to construct jetties for several miles into Breton Sound. These jetties have caused minor changes in water circulation patterns in both Breton and Chandeleur Sounds, but the impact of the changes on the ecology of the area is not known at this time.

Proposed widening of the channel to 750 feet and deepening to 50 feet would further accelerate environmental deterioration of the area. Large acreages of marsh would be lost to dredging and spoil disposal, lengthening of the channel to reach the 90 foot offshore contour would further disrupt circulation in the sounds, and the deeper channel would increase salt water intrusion and accelerate bank slumping.

The Houma Navigation Channel (Fig. 26) and the Barataria Waterway (Fig. 20) have environmental impacts similar to those of the MRGO, but they have been somewhat less severe because these channels are neither as wide nor as deep as the MRGO. One particular problem associated with the Houma Navigation Channel is the fact that it cuts diagonally across the "hydrologic grain" of the estuary, thereby creating a runoff shadow or fresh water deficient area south of the canal (Fig. 26). Increased salinities in this shadow area have accelerated marsh deterioration and land loss.

The proposed widening and deepening of the Barataria Waterway would have serious environmental implications. In addition to the direct loss of marsh as a result of dredging and spoil disposal, it would ac-

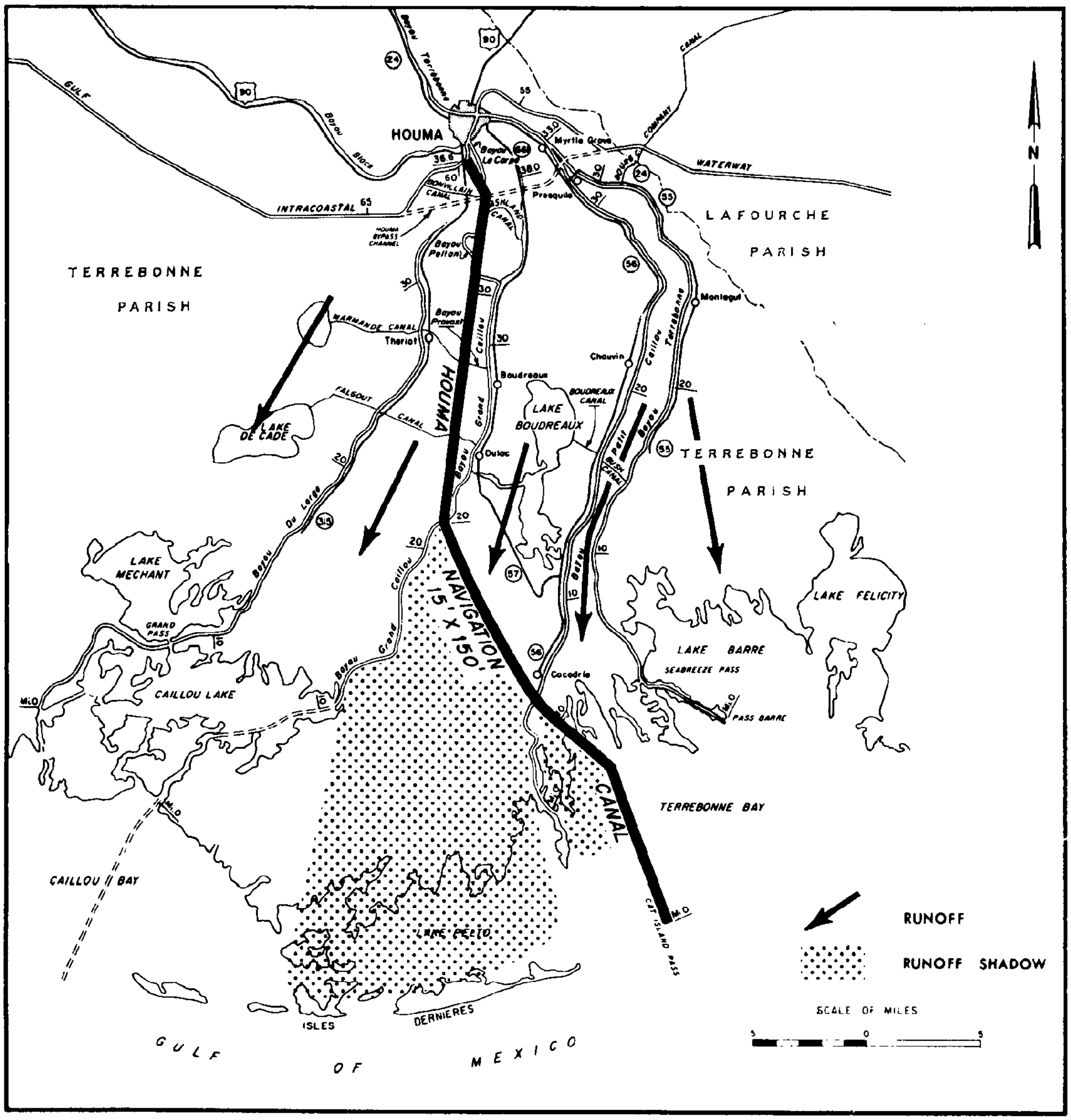


Fig. 26. Houma Navigation Canal and vicinity, Terrebonne Parish, Louisiana (Base after U.S. Army Corps of Engineers, 1968).

celerate runoff, increase salt water intrusion, increase tidal exchange and erosion, and disrupt the longshore drift of sand moving from Grand Isle to Grand Terre. The latter impact would most certainly accelerate erosion and deterioration of Grand Terre Island. This, in turn, would open the estuary system to the sea and cause additional increases in salinity and erosion. The net effect would be an acceleration of the deterioration of Louisiana's most productive estuary.

PETROLEUM INDUSTRY DREDGING

History and Development

Inspection of maps and aerial photographs reveals that a high proportion of the canals have been dredged in conjunction with petroleum exploration and production. In the mid-1930's, the first submersible drilling barge was built for inland waters. This innovation set the pattern for the modern petroleum industry in the south Louisiana wetlands. In 1938, barge-mounted draglines were first used in this area to excavate access canals for drilling barges (McGhee and Hoot, 1963). Prior to these developments drilling operations had been inhibited by poor foundation conditions in the coastal swamps and marshes. In some places it was possible to build tram roads into these environments, but such penetration was minor. However, the submersible drilling barge, teamed with the barge-mounted dragline and other specialized dredging equipment, opened the whole coastal zone to petroleum development. Submersible drilling barges moved down canals into swamps and marshes and were soon followed by waterborne pipe-laying equipment (Fig. 27).

Four basic types of equipment perform the bulk of modern petroleum-industry dredging. Hydraulic dredges cut into the water bottom with a big cutter head rotating on a long suction pipe. Earth dislodged by the cutter is sucked to the surface, where it is pumped to a spoil area. Suction-dredged spoil is left in several characteristic patterns. Most typically, it is deposited in small hillocks or mounds in the vicinity of the tail pipe where the slurry is discharged. These are usually along one margin of the dredge cut. Since the tail pipe is moved only periodically, the embankment formed by this type of spoil is often discontinuous.

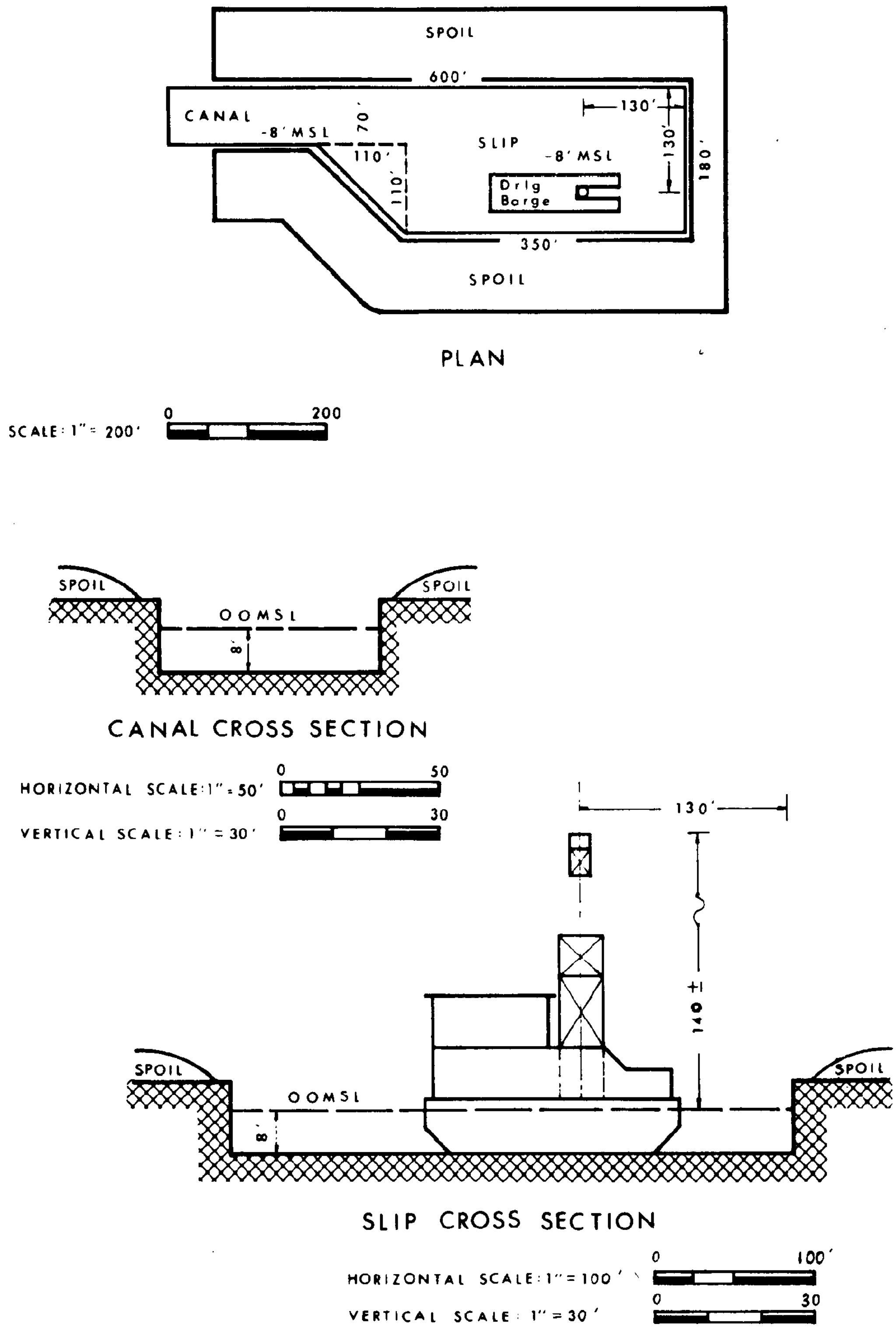


Figure 27. Configuration of typical oil drilling barge rig cut.

Sometimes in large jobs suction-dredged spoil is impounded by dikes. This is done where it is desirable to build an embankment or elevated area for construction, or when the material is to be used as future borrow material.

Bucket dredges are the workhorses of the petroleum dredging industry in coastal Louisiana. This type of machine consists of a dragline permanently fixed to a barge-type hull. This barge is equipped with three spud piles which can be thrust into the bottom to hold the barge in position during operation. Typically, the dredges are equipped to work with a 6- to 8- cubic yard clamshell type bucket. Bucket dredges usually leave a continuous embankment of spoil along one or both sides of the excavation. Spoil bank dimensions depend on the size of the excavation, the length of the boom, and the stability of the canal and spoil banks.

Spud barges are similar to bucket dredges, but the dragline is not permanently fixed to the barge. The spud barge is especially effective because the dragline can either be secured to the barge or operated on land on its crawler tracks. This versatility is invaluable in such jobs as clearing swamp locations and laying pipeline river crossings. Since the dragline is not fixed to the barge, the boom is shorter and the bucket is smaller than those usually found on bucket dredges. However, as in the case of the bucket dredge, spoil is heaped up into a bank immediately adjacent to the canal.

A fourth type of dredging equipment consists of a dragline mounted on a marsh buggy carriage. The marsh buggies are similar to those used to carry seismic equipment through the marsh. They are motorized, tracked vehicles equipped with large flotation pontoons. Their usefulness is limited primarily to marshy terrain because they do not operate well in deep water or stump-clogged swamp. This type of machine is used primarily for laying pipelines through the marsh areas. It simply cuts a ditch for floating in the pipe, eliminating the necessity for dredging a full-scale canal to accommodate the pipeline-laying barge. While this type of operation produces far less spoil, marsh buggy tracks often cause pronounced changes in the marsh surface, particularly in the areas of floating marsh, where the floating vegetation mat may be permanently damaged.

Dredging activities related to the petroleum industry fall into several categories, most involving either the making of drilling locations or the laying of pipelines. Secondary canals for crude-oil transport barges and production workboats are also numerous.

The occurrence of petroleum, natural gas, and sulphur deposits in south Louisiana is controlled by subsurface features, and there is rarely any relationship between surface morphology and the deeply buried deposits. Locations of wells and pipelines are dictated by the configuration of subsurface structures and stratigraphic traps. As a result, a random network of canals dredged for drilling rig access and field maintenance and production has evolved in the Louisiana wetlands. There is rarely any logical or orderly relationship between this maze of artificial waterways and natural surface features such as drainage pattern, shorelines, etc.

The development of an oil or gas field is a random but cumulative process; that is, the first exploratory well is usually drilled on the basis of some geophysical data. The exploratory well provides additional information which influences the location of the next well. Each new well drilled adds to the understanding of subsurface structure and stratigraphy and in its turn aids in the selection of new drilling sites. Thus, the full development of an oil and gas field cannot be planned in advance, and the scars left on the landscape are cumulative and somewhat haphazard.

The human factor further complicates canal configuration. After the geologist has selected the point at which he would like to drill, land men secure surface rights-of-way and permits for access canals to the proposed drilling site. The routing of the access canal is dictated largely by property boundaries and locations of navigable waterways, and it generally cuts across natural drainage lines and surface features at random angles.

Dikes or water control structures are usually required on both state-owned and privately owned land on access canals at points above and below the intersection of the existing waterway. Such structures are designed to minimize salt water intrusion and circulation change. There is usually a contract clause requiring perpetual maintenance of these structures by the petroleum or pipeline companies.

If the field is productive, a secondary network of canals and ditches evolves as collection pipelines are installed. This network also facilitates gauging and maintenance. Although the pipelines are controlled by surface features, as are the access canals, their location is rarely influenced by surface drainage pattern or morphology. Rather, they take the straight-line route between the producing field and the tank battery or master pipeline connection.

After a field has been fully developed, the net result is an ugly scar on the landscape. The integrity of the natural environment is drastically altered. Land has been lost directly through canal dredging, and natural drainage and tidal circulation are altered. Erosion rates are increased because of the resulting increased length or land-water edge, and there is an increase in the volume of water exchange. Bank erosion caused by wakes of boats engaged in production activities is a particular problem.

The Leeville and West Bay Fields, Case Studies

An attempt to measure the extent of environmental modification of oil and gas field on estuarine environments was made by comparing aerial photographs flown over two fields in 1952 with photographs made in 1969. The Leeville field (Fig. 28), located in Lafourche Parish in the vicinity of Leeville, Louisiana, is one of the older fields in south Louisiana, having been discovered in 1931. As of 1969, it had a total of 365 oil wells and 51 gas wells (Louisiana Geological Survey, 1969). The field, which includes 5,500 proved acres of oil and 4,000 proved acres of gas, is controlled by a salt dome structure. Although this is an old field, the 1969 statistics show that 7 new wells were drilled in that year for a total of 47,360 feet. After 38 years, the field is still being developed.

Figure 29 illustrates dramatically the changes that have resulted in the vicinity of the Leeville field during the 17-year period between 1952 and 1969. Alteration of surface conditions as a result of dredging is extensive. Measurements of the natural and man-induced environments taken from the two photographs are presented in Table 4.

The West Bay field in Plaquemines Parish shows a similar history of development (Fig. 30). It was discovered in 1940, and by 1969 a total of 645 oil wells and 41 gas wells had been drilled (Louisiana Geological Survey, 1969). Like the Leeville field, it is controlled by a salt dome structure. In 1969 it included 10,000 proved acres of oil, and 2,340 acres of gas. Figure 30 illustrates the increase in canals in the West Bay field during the period from 1952 to 1969. The extent of environmental modification is further illustrated in Table 5.

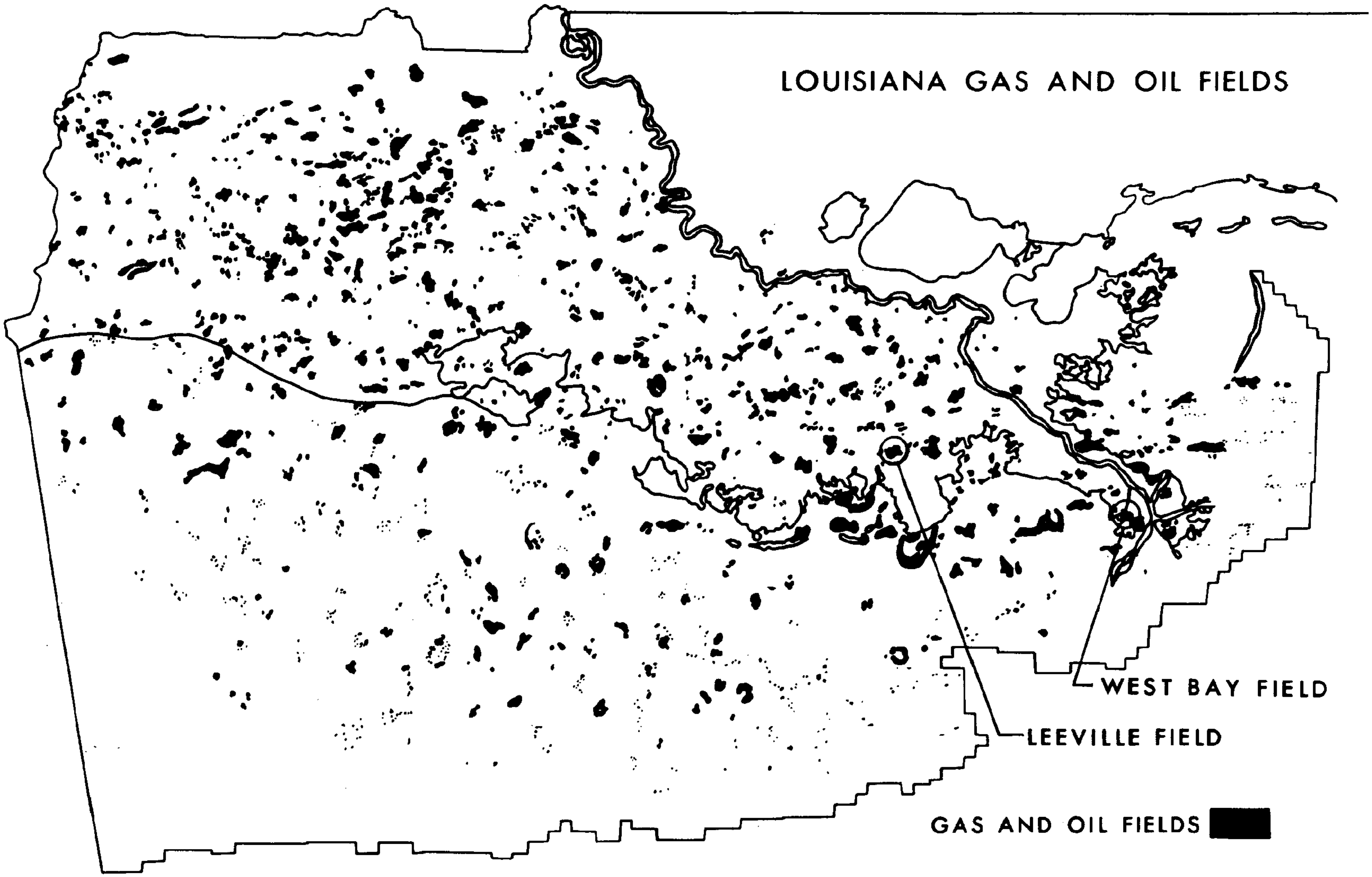


Figure 28. South Louisiana gas and oil fields. (After Gusey and Maturgo, 1971; original source data from Transcontinental Gas Pipeline Company.)

Figure 29. Comparative aerial photographs of the Leeville oil field, Lafourche Parish, Louisiana, 1952 and 1969. Location shown in Figure 1. The area is located along the old Bayou Lafourche distributary of the Mississippi River. This is an abandoned delta lobe which is undergoing gradual natural deterioration. The marsh surface in 1952 was still largely unbroken, but by 1969 a number of ponds had appeared (A). Tidal channels (B) show little change. Bayou Lafourche (C) serves as a major artery for both fishery and petroleum industry vessels. The intricate web of canals dredged for drilling rig access and production activities was already under development in 1952 but has been greatly expanded since that time. Scale of the photographs is approximately 1 inch to 2.25 miles.


B
C
1952

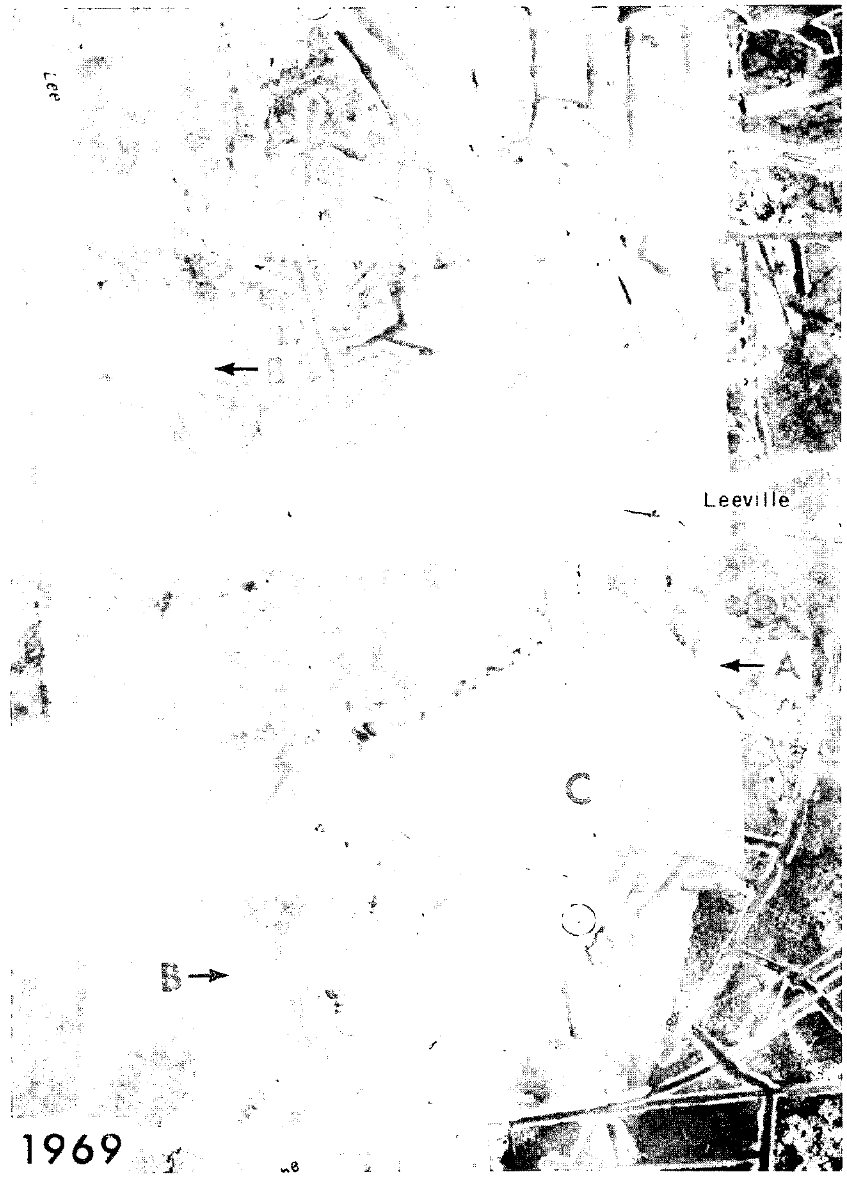

Leeville
A
B
C
1969

Table 4

Changes in Surface Environments in the Leeville Oil Field, 1952-1969.

Data from Comparison of Aerial Photographs.

Environment	% Surface Configuration*	
	1952	1969
Marsh	71.3	55.9
Tidal streams	4.9	3.2
Lakes and ponds	11.8	7.0
Navigation channels	1.0	2.9
Petroleum access canals	3.2	9.2
Petroleum rig cut canals	1.6	5.4
Spoil banks	5.4	15.2
Highways (including embankments)	.8	1.2
	100.0	100.0

Environment	Length in miles	
	1952	1969
Canals	30.2	65.3

*Total surface area of photo coverage = 22.8 mi^2.

Figure 30. Comparative aerial photographs of the West Bay oil field, Plaquemines Parish, Louisiana, 1952 and 1969. Location shown in Figure 1. The field is located in the lower western margin of the West Bay subdelta. This area has undergone drastic land loss through subsidence during the last 20 years. The marsh surface has become drowned, and only narrow bands of relatively high natural levee ridges remain (A). Bays in the interdistributary areas (B) are rapidly expanding. Areas with well-developed tidal stream networks (C) located near major distributaries have experienced the least amount of land loss through erosion. The margin of the landmass bordering the Gulf of Mexico (D) is deteriorating rapidly in most places.

Even though this area is undergoing rapid natural change, the most obvious difference between the two photographs is the development of the extensive web of canals and spoil banks associated with the petroleum industry. In addition to the canals, note waste disposal pits (E) and oil storage tanks (F). Scale is approximately 1 inch to 2.5 miles.


C
D
1952


TIGER
C
E
F
A
A
B
D
O
F
Pass du Bois
Pass la Grasse
1969

Table 5

Changes in Surface Environments in the West Bay Oil Field, 1952-1969. Data from Comparison of Aerial Photographs.

Environment	% Surface Configuration*	
	1952	1969
Marsh	49.7	25.4
Tidal streams	4.3	4.1
Lakes, ponds, and small bays	26.4	38.3
Open Gulf	10.4	8.9
Navigation channels	1.9	2.4
Petroleum access canals	2.6	11.1
Petroleum rig cut canals	1.8	2.9
Spoil banks	2.9	6.9
	100.0	100.0

Environment	Length in miles	
	1952	1969
Canals	16.6	35.6

*Total surface area of photo coverage = 12.5 mi^2.

Study of these two fields clearly illustrates major alteration of natural environments as a result of canal dredging. This raises the question as to whether such environmental alterations are beneficial or detrimental to biological productivity of the area. This study cannot answer that question. It is apparent, however, that channelization of the type associated with the fields studied causes major changes in surface runoff, tidal exchange, and water circulation. These, in turn, alter water chemistry, and floral and faunal characteristics.

Extent of Petroleum Resources in the Louisiana Coastal Area

If the Leeville and West Bay fields were isolated occurrences, there would be little need for comment. However, the coastal area of south Louisiana is exceptionally rich in petroleum resources; consequently, environmental modification associated with its recovery has been severe. Figures 28 and 31 illustrate the extent of oil and gas fields in the coastal Louisiana area. As shown in Table 6, by 1969 there were 506 known fields and a total of 25, 510 oil and gas wells in the 19 coastal Louisiana parishes. The majority of these wells are located in swamp and marsh environments.

The figures indicate that more than 10 percent of the total acreage of these coastal parishes is underlain by oil and gas pools. This implies that more than 10 percent of the surface is subject to modification as a result of activities associated with petroleum recovery. Table 7 presents a similar breakdown of oil and gas field statistics for the Louisiana offshore area. As of 1969, there were 224 fields and a total of 11,153 wells located in the offshore waters of the state. Only about 2 percent of the offshore area is underlain by proven fields at this time. Most experts agree, however, that the offshore area will be at least as productive as

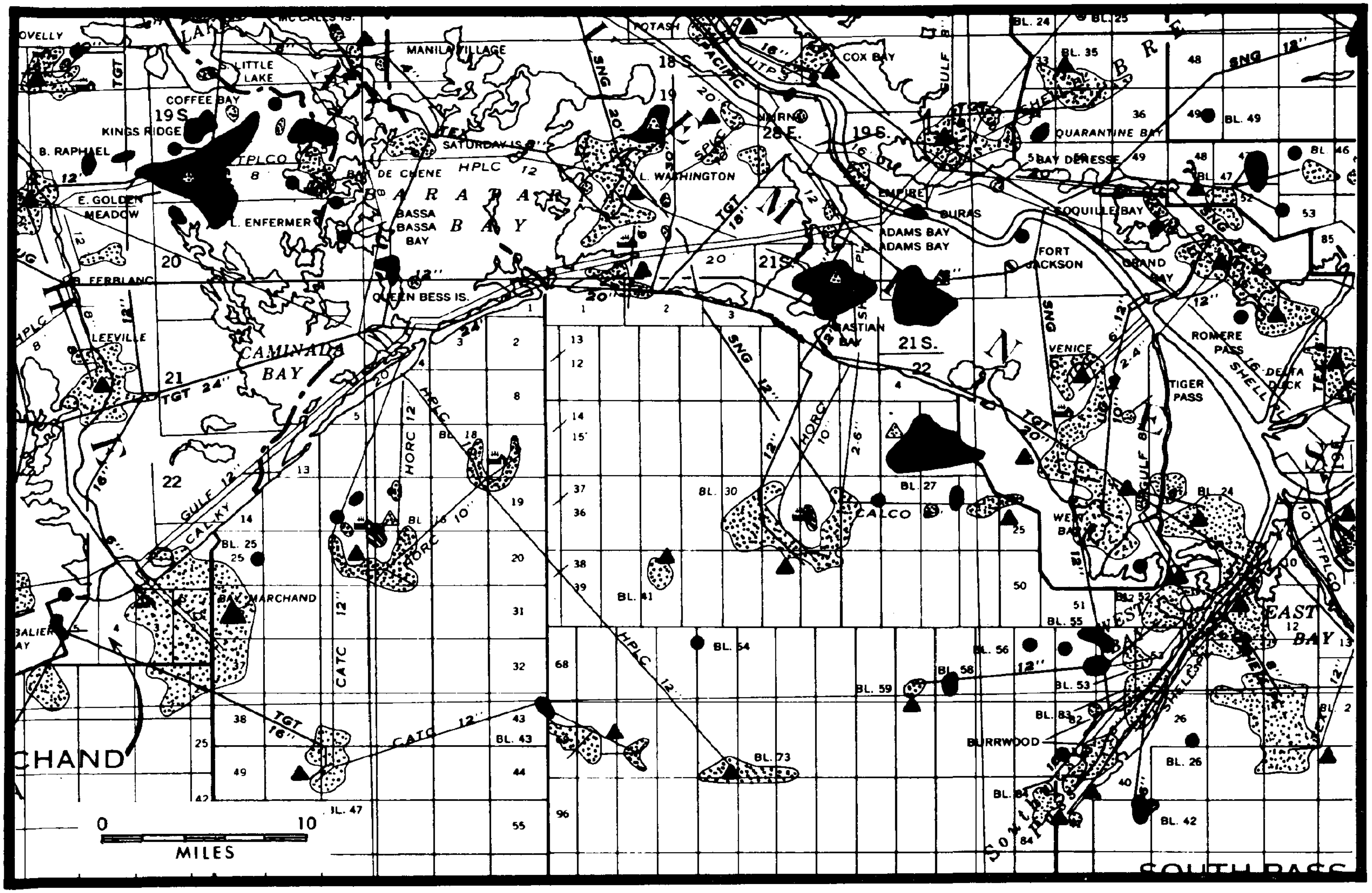


Figure 31. A portion of the oil and gas map of Louisiana showing density of oil and gas fields and pipeline network. Stippled areas show oil production and solid areas, gas production. Triangles indicate that the field has not been completely delineated. (After Louisiana Geological Survey, 1964.) .

Table 6

Oil and Gas Field Statistics for Coastal Louisiana Parishes
(Abstracted from Louisiana Geological Survey, 1969)

Parish	Number of Fields	Total No. Wells Through 1969 Oil	Gas	Total	Estimated Acres Proved Oil and Gas*	Total Acreage of Parish	%Total Area
Cameron	59	1,373	681	2,054	78,850	922,240	8.54
Vermilion	52	570	653	1,233	71,395	771,200	9.25
Iberia	21	826	248	1,074	36,450	376,960	9.66
St. Mary	31	1,977	697	2,674	76,390	399,360	19.12
St. Martin	32	1,175	290	1,465	44,090	471,040	9.36
Iberville	26	839	107	946	23,460	401,280	5.84
Pointe Coupee	12	269	36	305	13,660	129,920	10.51
West Baton Rouge	8	223	14	237	4,320	360,320	1.19
Assumption	17	196	147	343	23,791	227,840	10.44
Terrebonne	70	2,519	972	3,491	141,586	875,520	16.17
Lafourche	52	3,689	768	4,457	125,960	730,240	17.24
Ascension	4	180	51	231	5,580	192,640	2.89
St. James	8	103	53	156	8,640	161,920	5.33
St. John the Baptist	9	38	26	64	4,220	160,000	2.63
St. Charles	21	571	111	682	18,820	184,320	10.21
Jefferson	26	1,122	110	1,232	27,136	211,840	13.51
Plaquemines	46	4,247	488	4,735	86,430	659,200	13.11
Orleans	4	2	8	10	1,080	131,200	.82
St. Bernard	8	99	32	131	6,020	328,960	1.83
Totals	506	20,018	5,492	25,510	797,878	7,696,000	10.36

*This is a minimum figure for estimated proved acres. In the source data acreage is given as proved acres of oil and proved acres of gas. As the oil and gas areas are usually superimposed, the largest figure was taken for each field listed.

Table 7

Oil and Gas Field Statistics for Offshore Louisiana Areas (Abstracted from Louisiana Geological Survey, 1969. Acreage of offshore blocks provided by the Bureau of Land Management, Outer Continental Shelf Office)

Offshore Areas	Number of Fields	Total No. Wells Through 1969			Estimated Acres Proved Oil and Gas*	Total Acreage of Area	%Total Area
		Oil	Gas	Total			
Bay Marchand	1	785	44	829	13,620	31,979	42.59
Breton Sound	12	117	45	162	6,980	280,000	2.49
Chandeleur Sound	5	31	7	38	1,920	365,000	.52
East Cameron	18	14	190	204	20,550	1,714,228	1.19
Eugene Island	25	845	187	1,032	36,820	2,068,387	1.78
Grand Isle	9	1,015	129	1,144	23,840	573,986	4.15
Main Pass	19	992	150	1,142	39,800	1,487,712	2.67
Ship Shoal	26	678	276	954	36,180	1,806,401	2.00
South Marsh I.	12	202	139	341	17,700	1,350,570	1.31
South Pass	14	1,769	91	1,860	40,620	423,754	9.58
South Pelto	2	84	9	93	2,600	125,000	2.08
South Timbalier	14	568	121	689	18,720	1,416,956	1.32
Vermilion	25	118	330	448	28,780	1,980,234	1.45
West Cameron	22	65	371	436	38,240	3,113,493	1.22
West Delta	17	1,369	251	1,620	37,300	730,847	5.10
Total	224	8,716	2,437	11,153	368,470	17,468,547	2.10

*This is a minimum figure for estimated proved acres. In the source data acreage is given as proved acres of oil and proved acres of gas. As the oil and gas areas are usually superimposed, the largest figure was taken for each field listed.

the coastal parishes. Of particular interest here is the fact that virtually all of the production will be routed to refineries and markets through pipelines and waterways that traverse the Louisiana coastal wetlands.

In addition to these readily measurable effects, the quality of the environment and the wildlife and fisheries habitat is reduced within the general vicinity of the whole field. Although no statistics are presently available, it follows that biological productivity is also substantially reduced.

EVALUATION

Effects of the Mineral Extraction Industries on the Wildlife and Fisheries Resource

In an attempt to evaluate the effects of the petroleum industry on the wildlife and fisheries resources of coastal Louisiana, Gusey and Maturgo (1971) have compared drilling and production statistics with fishery statistics for the period 1939-1969. These authors point out that during the period that the oil and gas industry was emerging the wildlife and fisheries harvest showed an almost steady increase (Fig. 32). In 1969, Louisiana led all 50 states in the volume of fish and shellfish harvested, with a total of 1,106 million pounds valued at $56.7 million (Bureau of Commerical Fisheries, USDI, 1969). Estuarine-dependent species such as shrimp, menhaden, and oysters dominate the Louisiana fishery, accounting for approximately 90 percent of its value. The growth in this commercial fisheries industry has been paralled by increased importance of sports fishing.

Gusey and Maturgo also point out that during a significant portion of the period under consideration the population of fishermen and vessels occupied in commercial fishing has remained reasonably constant. Contrary to what has been reported, however, there has been a substantial increase in the number of fishermen and vessels occupied in commercial fishing for the period 1936-1969 (USDI). Major changes in harvesting technique and fishing gear have also increased the efficiency of the operation during this period. Further, the increase noted for total pounds of fish beginning in 1945-50 can be directly related to the development of the menhaden industry. The increase in harvest is indicative of the utilization of a previously unharvested resource, not an increase

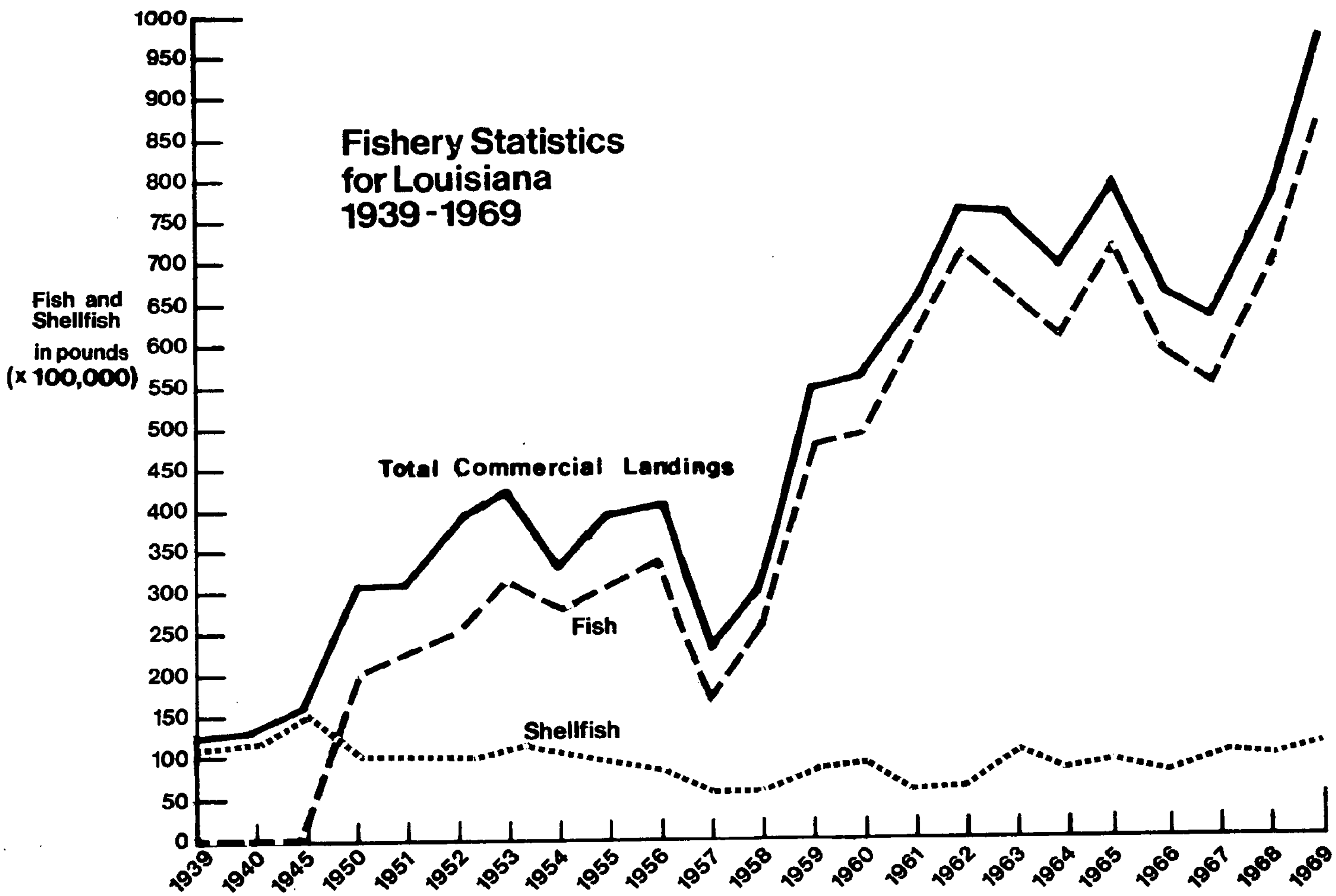


Figure 32. Fishery statistics for Louisiana, 1939-1969. (After Gusey and Maturgo, 1971). The increase in total pounds of fish beginning in 1945-50 can be directly related to the menhaden industry.

in production.

Waterfowl counts and harvest statistics of fur-bearing animals from the coastal Louisiana area are more difficult to evaluate. In the case of migratory waterfowl, wintering populations may be related largely to external factors such as conditions of nesting grounds. It is generally agreed, however, that during the mid-1950's waterfowl populations built to high levels. It is doubtful that these levels will ever be reached again. An upward trend in waterfowl abundance in recent years is attributed largely to intensified management practices in state and federal government-owned refuge areas.

As with waterfowl, population trends of fur-bearing animals are difficult to evaluate because they are controlled by such factors as biological competition and fluctuations in market price. The fur industry in Louisiana reached its peak in the 1940's and suffered steady decline until the late 1960's. The last few years have shown considerable improvement in the fur catch.

There seems to be little argument that sports fishing in the offshore area has benefited from the petroleum industry. This is largely the result of the hundreds of offshore drilling platforms that have been erected in the past 30 years. These rigs are truly million dollar "artificial reefs;" they serve not only as concentration points for fish and shellfish, but also as limited fish and shellfish production sites (Gusey and Maturgo, 1971).

Gusey and Maturgo drew several conclusions from their research that are pertinent to this study:

The relationship between oil and gas production and production

> operations and marine and other wildlife resources is not necessarily a tenuous one. Data which are available indicate that these industrial operations are compatible with the production and maintenance of economically and aesthetically valuable marine resources-- even in an area subject to more than 30 years of intrusion into the marine and coastal environment by one of the largest complexes of gas and oil facilities in the world.
>
> The "presence" of petroleum operations in the Gulf of Mexico fish and wildlife environment is evident, or even conspicuous. The "effect" of that presence is more difficult to describe, since it ranges from the intermittent escape of oil and tainting of shellfish to compatibility with a variety of species, including co-existence with major shellfish and waterfowl areas and enhancement of production and subsequent harvest of sport and commercial fish.
>
> Therefore, in degrees varying from desirable to less than desirable, there are many "effects" from oil and gas production facilities in the Gulf. Platforms have become an integral part of the marine ecosystem, and since no ecosystem is without flux, none of the "effects" are static or without variation or frequent change. Correspondingly, change or variation in the behavior and abundance of any marine organism should be anticipated and considered normal within the framework of an altered, but not necessarily damaged ecosystem.

While the above statement represents a rational appraisal of the data and a valid viewpoint held by a number of workers, it cannot be dismissed without comment. Data analyzed in this study indicate that dredging related to the petroleum industry has been a major contributor to land loss and marsh deterioration in coastal Louisiana during the past 30 years. Map studies show that approximately 16.5 square miles of land were lost each year in the coastal zone during this 30-year period (Gagliano and van Beek, 1970). Approximately 25% of this loss can be accounted for as a direct result of petroleum industry dredging.

The productivity of a given estuary system is directly proportional to the configuration of its component environmental parts and the kind and intensity of processes operating in the system. Estuaries in coastal Louisiana owe their high productivity to the large areas of marshes and swamps fringing open water bodies, to highly irregular shorelines providing thousands of miles of land-water contact and broad brackish water zones. Because these estuaries are a product of deltaic processes, it might be surmised that there is some ideal configuration which will result in maximum biological productivity. Under natural conditions, the productivity of the entire estuarine zone was high. Although productivity is still high, there are many indications of environmental deterioration (i.e., breaking up of marsh surfaces, shoreline erosion, salinity intrusion). History may record that peak biological productivity occurs in the Louisiana estuary late in the cycle of deterioration but that it is an ephemeral peak which is followed by steady decline as the estuary continues to deteriorate. Eventually, the system collapses completely and no longer functions as a viable estuary system. The present study indicates that in general, canals have drastically increased rates of deterioration and may contribute to the collapse of the highly productive estuarine systems along the Louisiana coast.

Drainage and Land Reclamation

There has been a recurring dream that the vast areas of swamp and marshlands in coastal Louisiana could be reclaimed in the fashion of the Netherlands and turned into a rich agricultural region. More recently, some visionaries see these areas as sites for extensive urban and industrial development. This view is not unique to Louisianians, but has often been expressed in reference to wetlands in general. The following quotation from a book by Paul Wagret (1959) typifies the Dutch approach to coastal engineering in low-lying coastal areas that has dominated professional thinking for several centuries:

> These swamps and coastal lagoons are often of little economic importance: left in their original state, without man's interference, these are but worthless regions used only for hunting and fishing, or as plant or animal reserves. The few wretched inhabitants are subject to endemic malaria. Such is the classic picture of deltas and coastal swamps from Louisiana to the Dobrogea, from the valli of the Po delta to the Grand Briere of the lower Loire.
>
> Man's intervention can miraculously transform these unfavourable natural environments, for he alone can change a brackish marsh into a rich corn-growing land, or reclaim an unhealthy and neglected region. The conquest of the polders by building of protective dykes, systematically planned or piecemeal, is essentially a triumph of human will; it is the imprint of civilization on the landscape. It has been said that every human settlement is compounded of land, water, and man.

Although still widely held, this viewpoint is open to challenge. In recent years, environmental scientists have learned that some of these "unfavourable natural environments," such as brackish marsh, are among the most productive places on earth. It has been established, in fact, that biologically, the brackish marsh is more productive than the "rich, corn-growing land" into which it might be transformed. Further, as more and more swamps and marshes are miraculously transformed by the hand of man, the "wretched inhabitants" come to realize that the natural landscape was very beautiful, and that which replaces it is often far less so. After they disappear, those things which were taken for granted are recognized as amenities which contributed to the quality of life of the area's residents.

In the case of the coastal Louisiana wetlands, it is now abundantly clear that they represent a resource that transcends state boundaries and is of national importance, and yet they are being destroyed at an alarming rate. The priorities that dictated reclamation of the Netherlands were based on population pressures and need for agricultural land in western

Europe and were quite different from those of twentieth century Louisiana. A fresh approach to regional development is demanded.

New Orleans is a major locus of encroachment into wetlands environments. As brought out earlier in this report, with the growth of the city most of the higher grounds in the area that were available were already committed to urban development by the late nineteenth century. The expansion into the swamps and marshes, which began at that time, continues.

Demands for additional land transportation routes to support expansion has accelerated encroachment into the wetlands. With the older, inefficient roadways and adjacent developments already crowding the higher ground formed by natural levees and with Lake Pontchartrain and the Mississippi River forming natural barriers to the north and the south, respectively, it was inevitable that urban growth and transportation routes would be at the expense of wetlands lying adjacent to already developed areas to the east and the west. New highways usually create corridors for development which, in turn, results in demands for flood protection and land reclamation projects. Associated with such development are requirements for additional power, sewage treatment facilities, solid waste disposal, etc. The cumulative growth of the city took place in the absence of a clear understanding of the wetlands environment or the intrinsic value of such lands. Although man is more aware of environmental values today, various pressures for development have a tendency to foreclose, in some cases, adequate consideration of environmental consequences.

Utilization of lands well-suited for residential, commercial, and industrial uses which lie less than 30 miles north of the city (Fig. 33)

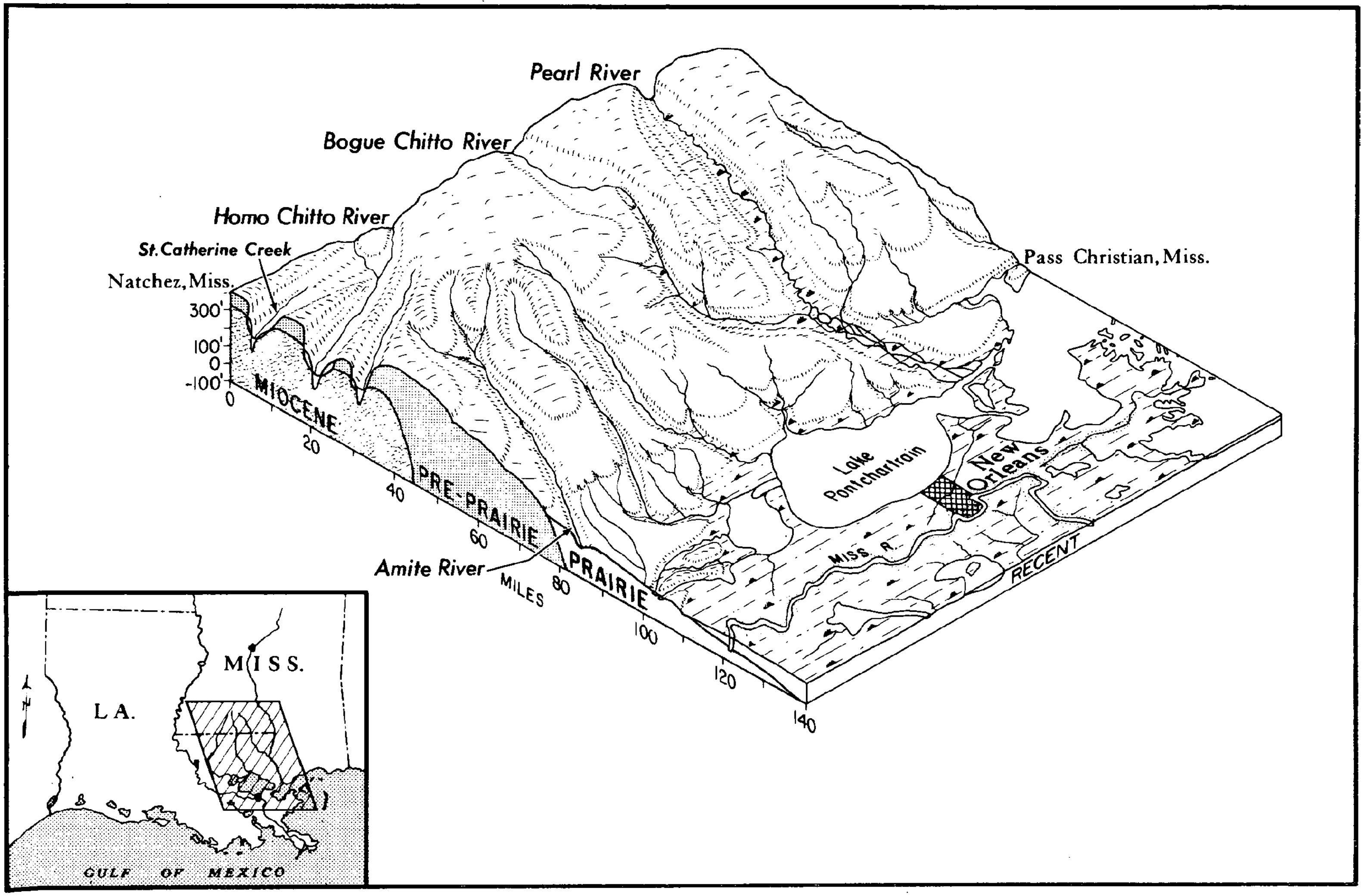


Figure 33. Geologic setting of the New Orleans area. In contrast to the wetlands in the immediate vicinity of the city Pleistocene terrace surfaces on the north shore of Lake Pontchartrain are well above sea level, naturally drained, and in general ideally suited for urban development.

across Lake Pontchartrain, offer one alternative to further wetlands encroachment. Here, Prairie and older Pleistocene terrace lands are well above sea level, gravity drained, and endowed with good ground water supplies. Improved roadways across Lake Pontchartrain, along with the development of rapid transit systems, could direct the city toward these areas and reduce sprawl into the wetlands. While such a solution would take some pressure off the wetlands, this alternative is not without its drawbacks. It would, in effect, direct people out of the city. New Orleans, and the surrounding parishes constituting the greater metroploitan area, must find space for young and productive citizens from within and without and for new industry if the city is to survive as a viable entity. The area can ill afford to become a refuge for the poor and aged, nor can it prosper as a parking lot for people who drive in from others areas solely for work. Another alternative would involve compatible multiuse development in accordance with the concept of the New Town-In Town previously described.

Canals and Dredging

In this report an attempt has been made to identify the types and extent of canals in the Louisiana coastal zone. Environmental impacts of the canals and dredging in this region can be summarized as follows:

Negative Impacts

- Direct loss of productive habitat through dredging;
- Direct loss and/or reduction in habitat quality through spoil disposal;
- Salt water intrusion causing faunal and floral changes;
- Increased storm-generated surge;
- Accelerated erosion resulting from increased length of land-water interface;
- Increase in runoff rate resulting in loss of fresh water storage;

- Modification of runoff pattern, often creating fresh water deficient areas;

- Accelerated erosion resulting from increase in tidal prism volume;

- Changes in circulation patterns in bays and sounds;

- Accelerated erosion resulting from boat -generated wash;

- Accelerated erosion along unstable canal banks;

- Alteration and/or disruption of longshore drift of sand;

- Serve as development corridors;

- Introduce agricultural, urban, and industrial pollutants;

- Canals segment natural areas, often resulting in drainage and development in resulting smaller units;

- Destruction of unique natural habitats and environments;

- Destruction of historic and archeological sites;

- Reduced aesthetic quality: linear artificial elements usually have less aesthetic value than natural elements;

- Pre-empts planning process.

Positive Impacts

- Increase in land-water interface;

- Spoil may create new habitats and increase habitat diversity;

- Increase access for sports, recreation, and commercial activities.

This study has failed to reveal a single navigation canal in coastal Louisiana that has not had some negative impacts. However, recognizing the value of the coastal waterway system to the commerce and industry of the state we must find ways to continue to use the system while reducing environmental impact.

As previously discussed, of all navigation canals within the study area, the Mississippi River-Gulf Outlet has had the greatest negative environmental impact. In fact, 17 of the 19 negative environmental impacts listed above can be associated with the MRGO. The canal has accelerated deterioration of a major segment of the Louisiana coastal zone.

Although the magnitude of the impact may vary, similar problems are associated with most navigation channels, (existing and proposed) that penetrate the estuarine zone from the Gulf shore. Impact analysis of each of these projects on an individual basis seems to be a fruitless task. Perhaps a more fundamental problem is to delineate the ultimate extent and configuration of the navigation canal network in coastal Louisiana. If this task were accomplished it would then be possible to evaluate cumulative impact on the natural system and to devise alternative routings and designs that would minimize detrimental effects.

It is our task here, not to deliver indictments against management decisions made in the past, but to identify the causes for environmental deterioration and land loss in the coastal wetlands. Out studies indicate that canals dredged in conjunction with the extraction of subsurface minerals have been a major contributor. Evaluation of the history of the West Bay and Leeville fields suggests several guidelines which should be applied as soon as possible to all oil and gas fields in order to reduce the rate of deterioration and loss. They are as follows:

- Directional drilling of the type used in offshore operations should be employed wherever possible to reduce the number of access canals;
- The surface configuration should be a critical factor in choosing new well location sites;
- Pipelines, canals, spoil banks, etc., should be confined to zones designated to provide the least amount of environmental alteration. This will be critical during

the next 20-30 years as offshore production becomes fully developed because this production will also be routed through the coastal wetlands;

- Geometry of the canal network and spoil disposal should enhance the natural environment wherever possible and should be related to some future use;
- Pipelines should require an environmental impact statement;
- Pipelines should be buried and canals backfilled whenever possible, (push method);
- Marsh buggy traffic should be minimized. Repeated traverses should not be made over the same area;
- Blanket environmental impact statements treating dredging and spoil disposal related to both well locations and pipelines are totally inadequate. Fields and pipelines must be evaluated on an individual basis;
- A systematic procedure for corridor selection as well as specific design should be applied to all such projects.

The scars left on the coastal landscape in south Louisiana by mineral extraction industries are comparable in many ways to the vast open pit mines of Appalachia. It is doubtful that they will ever heal.

Since the canals do exist, some effort should be made to find a use for them. Perhaps they could be utilized in mariculture. Spoil banks provide a unique habitat in the wetland landscape that might offer opportunities for agriculture, game management, and/or recreation.

Routing of offshore production through the coastal zone is a crucial problem. The old axiom that a straight line is the shortest distance between two points must be reexamined. It is doubtful that the Louisiana coastal zone can sustain another 30 years of attrition through canal dredging at the present rate.

SUMMARY AND CONCLUSIONS

This report constitutes a partial inventory of selected human impact in the Louisiana Coastal Zone. An attempt has been made to demonstrate that the process of canalization of this deltaic coast has progressed in a somewhat random fashion resulting from resource exploitation and special geographic opportunities for inland navigation. Wetland reclamation has likewise increased without the benefit of regional planning and has been driven primarily by pressures for short-term econimic gain. Viewing these processes in historic and regional perspective it is painfully apparent that the cumulative effect has been very severe on the systems that maintain the natural character and biological productivity of the region. The capacity of the systems to respond to modification and to absorb impact has been approached on a trial and error basis. It has been well documented that this approach often leads to total and sudden collapse of the supporting natural systems. Land loss studies indicate that the Mississippi Delta System has already been seriously impaired. It may still be possible to reverse the present trend of deterioration and partially restore the system to a more favorable balance. However, if present policies regarding dredging and land reclamation obtain for another decade this option may be closed.

In addition to the above conclusions several major recommendations can be derived from the study. First, there is a critical need for comprehensive regional planning in the coastal zone. Although a number of major planning efforts are underway in various government agencies and non-government corporations, effective coordination is still virtually absent. In the highly productive and delicately balanced coastal area planning must follow the environmental planning method.

The principles are scientifically sound and established in other areas (See for example Ian McHarg's "Design With Nature"). Environmental considerations should carry at least as much weight as engineering, economic, social, and political considerations in the decision making process. Appropriate funding should be written into every major project to cover professionally conducted environmental research and planning. The size of the environmental study effort should be in proportion to the total primary and secondary impact and/or the total cost of the proposed project. In addition to project-by-project evaluation there is a need for cumulative impact assessment. There is also a continuing need for resource inventory, environmental monitoring and basic research in the study area. The dynamic nature of the area demands that these be on-going programs. Finally it is not enough to evaluate impact and restrict land use, it is equally important to initiate environmental management programs to maintain and restore the productivity and desirable characteristics of the natural systems operating in the area. In most cases the balance in these systems has been so greatly altered that they are no longer self-maintaining. Management and restoration programs should be initiated for the barrier islands, freshwater overflow swamps and lakes, brackish marshes, estuarine nursery areas, and areas of active deltaic sedimentation. Unless a comprehensive multiuse management plan is developed and implemented for the Louisiana coastal area within the present decade one of the nation's most productive natural systems will be destroyed.

ADDENDUM

After completion of the preceeding report, additional measurements of man-made water bodies were undertaken to more closely identify the human factors responsible for land loss in coastal Louisiana. All canals and ponds appearing on 1969 aerial photo mosaics in the Barataria-Terrebonne area, comprising about one-fourth of the coastal zone, were classified and measured. In an area of 5, 258 $miles^2$, bounded by the Mississippi River and the east levees of the Atchafalaya Floodway and extending to the Gulf, 106 $miles^2$ of canals were measured, or about 2% of the total area. The mineral extraction industries are responsible for 65% of the total dredging; drainage canals account for almost 21% and navigation canals for 11%. Becasue of the significance of this new data, a summary plate has been included in an attached map packet. This plate is titled "Canals, Barataria-Terrebonne Sheet," and is an excerpt from the "Environmental Atlas and Multiuse Management Plan for South-Central Louisiana" (Gagliano, et al., 1973).

S. M. Gagliano
December, 1973

BIBLIOGRAPHY

Anonymous, 1970. New Orleans Will Build $395 Million Port. Ocean Industry, April, 1970, pp. 88, 129-134.

Amstutz, D. E., 1964. Analysis of the Salinity Regime of the Mississippi River-Gulf Outlet Channel. Texas A&M Univ., A&M Projects 286-1 and 299. Tech. Rept. 64-21T, 59 pp.

Ayres, Q.C., and D. Scoates. Land Drainage and Reclamation. New York, 1939.

Barrett, B., 1970. Water Measurements of Coastal Louisiana. Louisiana Wild Life and Fisheries Commission, U. S. Dept. of the Interior Fish and Wild Life Service, Bureau of Commercial Fisheries Project 2-22-R of P. L. 88-309, 196 pp.

Bureau of Commercial Fisheries, USDI, 1969. Fisheries of the United States, 1969. Bur. of Comm. Fisheries, C. F. S., No. 5300, March, 1970.

Chabreck, R. H., 1971. The Size, Distribution, and Vegetation of Ponds and Lakes along the Louisiana Coast. Louisiana Cooperative Wildlife Research Unit, Louisiana State Univ., Baton Rouge, submitted to U.S. Army Corps of Engineers and Louisiana Wild Life and Fisheries Comm., 18 pp.

Gagliano, S. M., and J. L. van Beek, 1970. Geologic and Geomorphic Aspects of Deltaic Processes, Mississippi Delta System. Hydrologic and Geologic Studies of Coastal Louisiana, Report No. 1, Coastal Resources Unit, Center for Wetland Resources, LSU, Baton Rouge, La.

Gusey, W. F., and Z. A. Maturgo, 1971. Petroleum Production and Fish and Wildlife Resources, the Gulf of Mexico. Louisiana Environmental Conservation Dept., Shell Oil Co., New York, 38 pp.

Harland Bartholomew and Associates, 1959. A General Plan for New Orleans East, New Orleans, La. Prepared for New Orleans East, Inc., 39 pp.

Harrison, Robert W., 1947. Land Economic Research in the Alluvial Valley of the Lower Mississippi River. Journal of Farm Economics, Aug., 1947.

Harrison, Robert W., 1948. Should Louisiana Swamplands be Reclaimed? New Orleans Port Record, Feb., 1948.

Harrison Robert W., and Walter M. Kollmorgen, 1947. Past and Prospective Drainage Reclamations in the Coastal Marshlands of the Mississippi River Delta. Journal of Land and Public Economics, August, 1947.

Harrison, Robert W., 1961. Alluvial Empire. Arkansas, Pioneer Press.

Louisiana Geological Survey, 1964. Oil and Gas Map of Louisiana. Louisiana Dept. of Conservation, Louisiana Geological Survey.

______, 1969. Summary of Field Statistics and Drilling Operations. Louisiana Dept. of Conservation, Louisiana Geological Survey, 123 pp.

McGhee, E., and C. Hoot, 1963. Mighty Dredgers, Little Known Work Horses of Coastal Drilling, Producing, Pipelining, Now 25 Years Old. Oil and Gas Journal, March 4, 1963, pp. 150-153.

McNamara, J. P., 1969. Projected Development for the East New Orleans Lakefront. Shore and Beach, April, 1969, pp. 16-18.

Okey, Charles W., 1918. Wetlands of Southern Louisiana and Their Drainage. U.S. Dept. of Agriculture, Bulletin 652: 1-67.

Perret, W. S., B. B. Barrett, W. R. Latapie, J. F. Pollard, W. R. Mock, G. B. Adkins, W. J. Guidry, and C. J. White, 1971. Cooperative Gulf of Mexico Inventory and Study, Louisiana. Phase I. Area Description. Louisiana Wild Life and Fisheries Commission, New Orleans, 175 pp.

R. Dixon Spears Associates, Albert Switzer Associates, and Albert Volkert and Associates, 1970. New Orleans Airport Selection Site Study. Prepared for the New Orleans Aviation Board.

Rounsefell, G. A., 1964. Preconstruction Study of the Fisheries of the Estuarine Areas Traversed by the Mississippi River-Gulf Outlet Project. U. S. Fish and Wildlife Service, Fisheries Bulletin, Vol. 63, No. 2, pp. 373-393.

Saucier, R. T., 1963. Recent Geomorphic History of the Pontchartrain Basin, Louisiana. Louisiana State Univ. Press, Coastal Studies Series, No. 9, Baton Rouge.

U. S. Army Corps of Engineers, 1968. Corps of Engineers Projects in Coastal Louisiana and the Atchafalaya Basin, New Orleans District.

________, 1971. Water Resources Development, Louisiana, Lower Mississippi Valley Division. Vicksburg, 159 pp.

Wagret, Paul, 1959. Polderlands.